

526.9
In 2g
1903/04

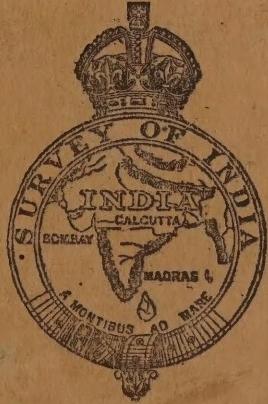
GENERAL REPORT
ON THE
OPERATIONS
OF THE
Survey of India
ADMINISTERED UNDER
THE GOVERNMENT OF INDIA

DURING

1903-04.

PREPARED UNDER THE DIRECTION OF
COLONEL J. R. HOBDAY, I.A.,
OFFICIATING SURVEYOR GENERAL OF INDIA.

THE LIBRARY OF THE
JUL-22 1925
UNIVERSITY OF ILLINOIS



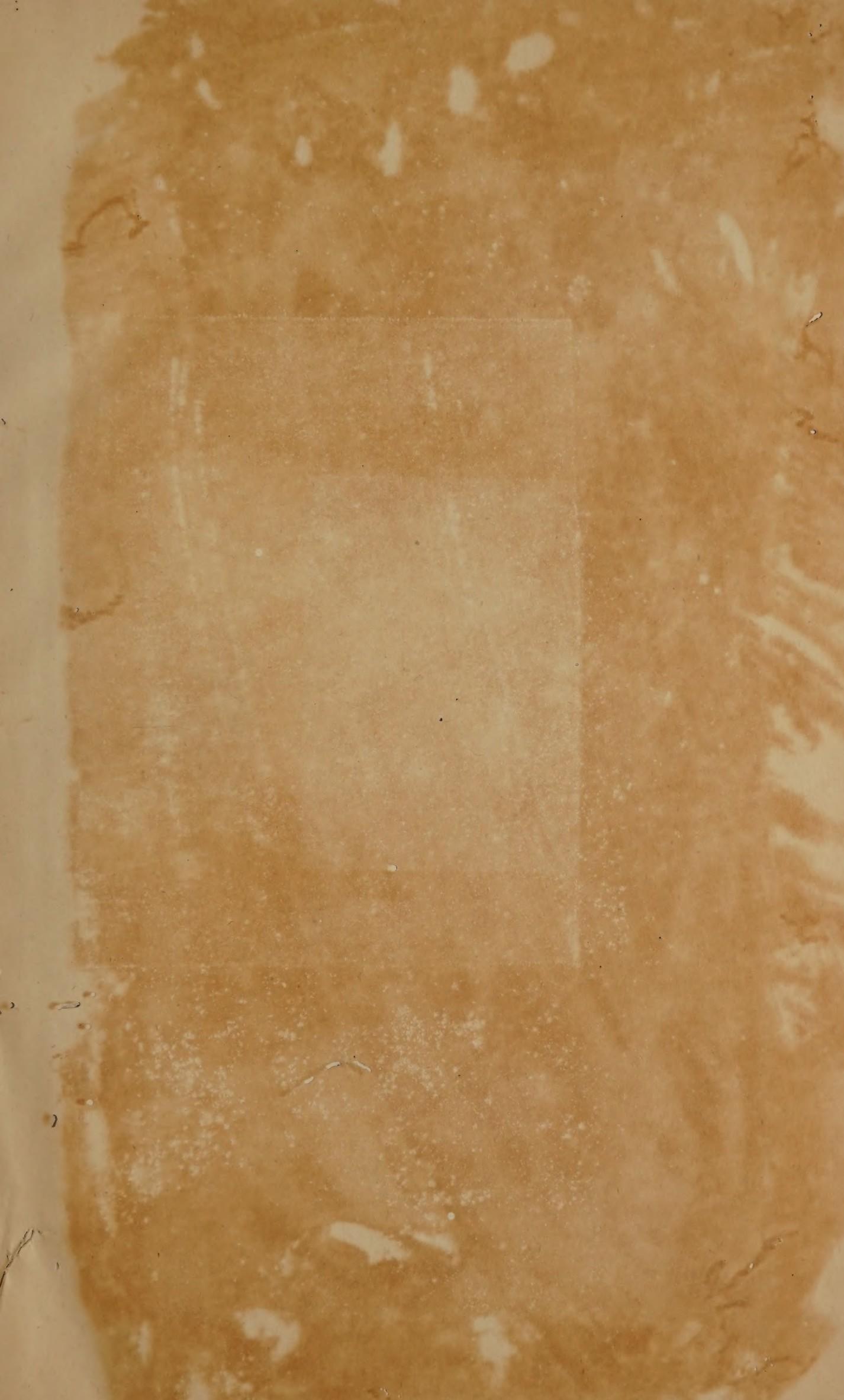
CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1905.

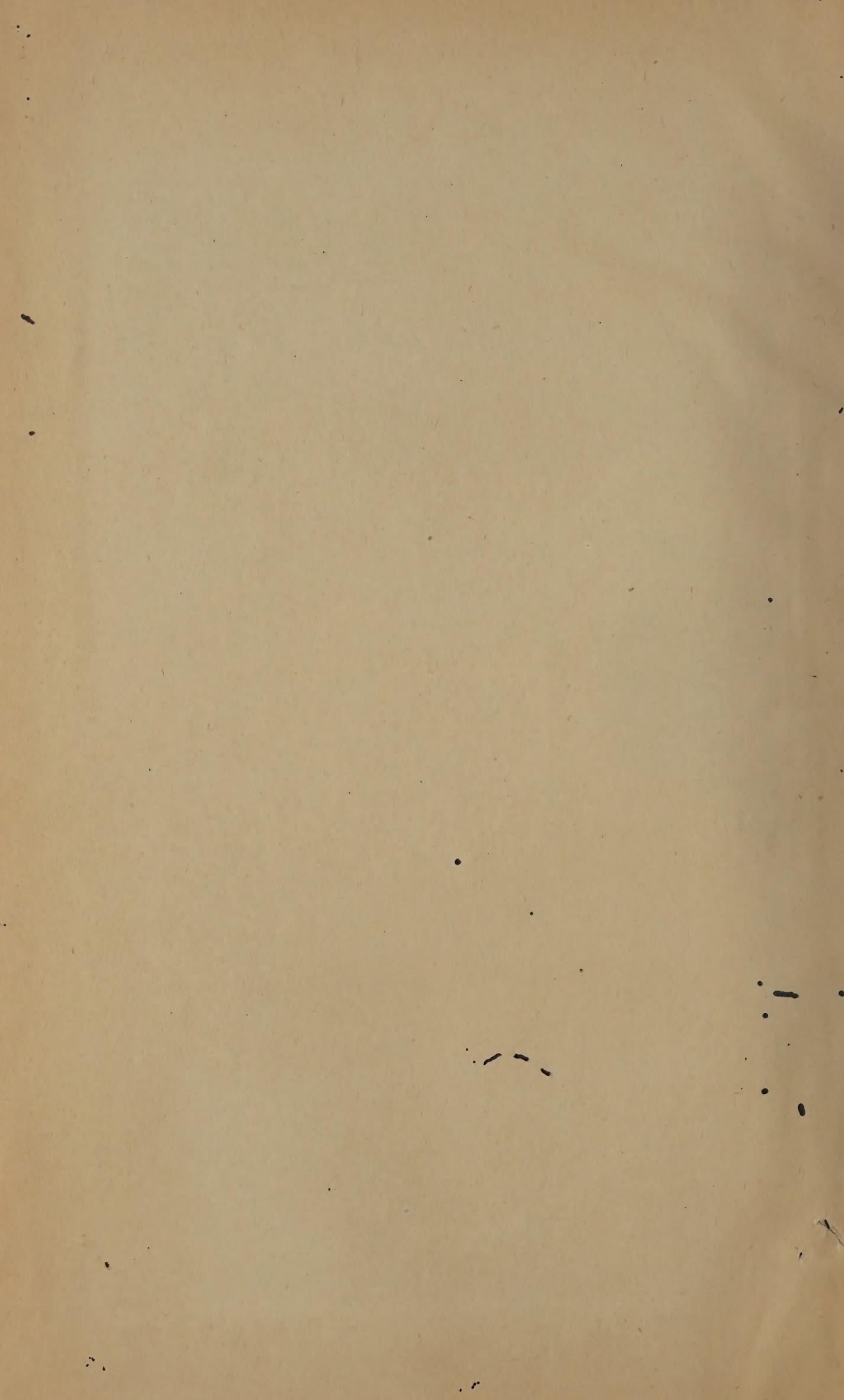
Price Two Rupees or Three Shillings.

THE UNIVERSITY
OF ILLINOIS

LIBRARY

q 526.9
In2g
1903/04





THE LIBRARY OF THE
JUL 22 1925
UNIVERSITY OF ILLINOIS

GENERAL REPORT
SURVEY OF INDIA
1903-04.

*Agents for the sale of Books published by the Superintendent of Government Printing,
India, Calcutta.*

IN ENGLAND.

E. A. ARNOLD, 41 and 43, Madox Street, Bond Street, W., London.
CONSTABLE, & Co., 16, James Street, Haymarket, W., London.
P. S. KING & SON, 2 and 4, Great Smith Street, Westminster, London.
KEGAN PAUL, TRENCH TRÜBNER & Co., Charing Cross Road, London, W.C.
BERNARD QUARITCH, 15, Piccadilly, London.
B. H. BLOCKWELL, 50 and 51, Broad Street, Oxford.
DEIGHTON BELL & Co., Cambridge.

ON THE CONTINENT.

R. FRIEDLÄNDER & SOHN, 11, Carlstrasse, Berlin, Germany.
OTTO HARRASSOWITZ, Leipzig, Germany.
KARL HIERSEMANN, Leipzig, Germany.

ERNEST LEROUX, 28, Rue Bonaparte, Paris, France.
MARTINUS NIJHOFF, The Hague, Holland.

IN INDIA.

THACKER, SPINK & Co., Calcutta and Simla.
NEWMAN & Co., Calcutta.
S. K. LAHIRI & Co., Calcutta.
R. CAMBRAY, & Co., Calcutta.
HIGGINBOTHAM & Co., Madras.
V. KALYANARAMA AIYER & Co., Madras.
G. A. NATESON & Co., Madras.
THACKER & Co., Ltd., Bombay.
A. J. COMBRIDGE & Co., Bombay.
D. B. TARAPOREVALA, SONS & Co., Bombay.
RADHABAI ATMARAM SAGOON, Bombay.
N. B. MATHUR, Superintendent, Nazair Kanun Hind Press, Allahabad.
Rai Sahib M. GULAB SINGH & SONS, Mufid-I-Am Press, Lahore.
SUPERINTENDENT, AMERICAN BAPTIST MISSION PRESS, Rangoon.

GENERAL REPORT

ON THE

OPERATIONS

OF THE

Survey of India

ADMINISTERED UNDER

THE GOVERNMENT OF INDIA

DURING

1903-04.

PREPARED UNDER THE DIRECTION OF
COLONEL J. R. HOBDAY, I.A.,
OFFICIATING SURVEYOR GENERAL OF INDIA.

THE LIBRARY OF THE
JUL 22 1925
UNIVERSITY OF ILLINOIS



CALCUTTA:

OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.

1905.

CALCUTTA:

GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.



g 526.9
Inag
1903/04

CONTENTS.

PART I.

SUMMARY.

	PAGE.
Administration	1
Field Parties	2
Outturn	4
Topographical Surveys	4
Forest Surveys	5
Cadastral and Traverse Surveys	6
Trigonometrical Surveys	7
Special Operations	7
Geographical Surveys	7
Head-Quarters Offices, Calcutta	8
Branch Offices, Dehra	15
Local Drawing Offices	16
Establishment	17

PART II.

THE OPERATIONS OF FIELD PARTIES.

PARTY.	PAGE.
TOPOGRAPHICAL SURVEYS.	
1. Central Provinces	19
3. Lower Burma	20
10. Upper Burma	21
11. "	22
12. Sind	23
14. United Provinces of Agra and Oudh	24
15. North-West Frontier	25
18. Punjab	26
FOREST SURVEYS.	
9. Forests	28
17. Bombay Presidency	29
19. Madras	31
20. Burma	33
CADASTRAL AND TRAVERSE SURVEYS.	
4. Bengal	35
7. Burma	40
8. United Provinces of Agra and Oudh	42
Detachment, Godávari	45
" Assam	46
TRIGONOMETRICAL SURVEYS.	
24. Triangulation	47
SCIENTIFIC OPERATIONS.	
22. Latitudes	48
23. Pendulums	49
25. Tidal and Levelling	51
26. Magnetic	53
TABULAR STATEMENTS.	
Outturn of work of Field Parties	56
Cost-rates	60
" of Scientific Parties	62

APPENDIX.

PAGE:

Narrative Report by Captain M. O'C. Tandy, R.E., on Aden Boundary Survey	
Report by Captain H. Wood, R.E., with a preface by Colonel St. G. C. Gore, C.S.I., R.E., on the identification and nomenclature of the Himalayan peaks as seen from Katmandu, Nepal.	v
Narrative Report by Captain C. H. D. Ryder, R.E., on Tibet Survey	xv
An account of the Scientific work of the Survey of India by Lt.-Col. S. G. Burrard, F.R.S., R.E.	xxv
Note by Lieut.-Colonel S. G. Burrard, F.R.S., R.E., on the great sunspot of 1903	xxxix
Statement of Magnetic Observations by No. 26 Party	xxxix

ILLUSTRATIONS.

Portrait of Colonel St. G. C. Gore, C.S.I., R.E.	Frontispiece.
Picture of the great sunspot of February 1903	To face page xxxix

MAPS.

TO PAGE

India, showing progress of Imperial Surveys to 1st October 1904	i
Index chart to the Trigonometrical Survey of India	i
" to the Survey Operations in Central Provinces	19
" " Topographical Survey in Burma, North of Latitude 18°	20
" " " " South of " 18°	20
" " " " Sind	23
" " Survey Operations in the United Provinces of Agra and Oudh	24
" " " " in Punjab	26
Map of India showing progress of Forest Surveys	28
Index to the Cadastral Survey in Bengal	35
" Traverse Survey in Bengal	35
" Revenue Survey in Burma, North of Latitude 18°	40
" " " " South of " 18°	40
" Cadastral Survey in the United Provinces	42
" Traverse " " " "	42
" Godávari Cadastral Survey	45
" Survey Operations in Assam	46
" Indian Atlas showing work in hand on 1st October 1904	62
" " " " sheets published to 1st October 1904	62
" Aden Survey	iv
Sketch Map of part of Nepal	xiv
Panoramic profile of the hill ranges of Nepal from Kaulia hill	xiv
" " " " " Mahadeo Pokra hill	xiv
Map of India illustrating the work of the Magnetic Party	xliii

THE HISTORY
OF THE
REPUBLIC OF LUXEMBOURG



THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

Published under the direction of Lieut.-Colonel F. B. Longe, R.E., Surveyor General of India,
May 1905.

Reg. No. 821-S. 05.

GENERAL REPORT
ON THE
Operations of the Survey of India
DURING THE SURVEY YEAR
1903-1904.

PART I.

SUMMARY.

ADMINISTRATION.

1. The operations that are now reported on are for the survey year ending 30th September 1904.

2. Colonel St. G. C. Gore, C.S.I., R.E., Surveyor General, directed the administration of the department up to 23rd February 1904, when, on his retirement, Lieutenant-Colonel F. B. Longe, R.E., succeeded him.

3. The office of the Deputy Surveyor General was held by Colonel J. R. Hobday, I.A., throughout the year.

4. Mr. J. Eccles, M.A., officiated as Superintendent, Trigonometrical Surveys, up to 3rd November 1903, when Major S. G. Burrard, F.R.S., R.E., returned from furlough and resumed charge.

5. Major P. J. Gordon, I.A., held charge of the office of the Superintendent, Forest Surveys, Bengal Presidency, up to the 6th November, when he proceeded on a year's combined leave, Major C. W. H. Symonds, I.A., officiating for the remainder of the year.

On the 1st April 1904, all Forest Surveys in India were amalgamated

By a resolution of the Government of India, and placed under the superintendence Revenue and Agricultural Department (Forests), of one officer as Superintendent, Forest No. 3-2135-F, dated 11th February 1904. Surveys, having position and powers similar to those of the Superintendent, Trigonometrical Surveys. The Forest Survey Branch thus constituted, consists at present of 4 survey parties, uniformly governed by the rules and regulations of the Survey of India. The Head-Quarter Office of the Branch at Dehra Dún will continue to keep up the map records of the Forest Department and will prepare such special maps as may be sanctioned by the Inspector General of Forests; it will also store and issue all Forest Survey maps. It is hoped that uniformity in standard and system will be secured by amalgamation. The cost of all Forest Surveys on scales of not less than 4 inches to the mile, will be distributed in the proportion of 30 per cent. to topographical survey, and 70 per cent. to Forests.

Inspection tours of Administrative Officers.

6. Lieutenant-Colonel Longe, R.E., Surveyor General, left Calcutta on the 11th April for Simla, stopping on the way to inspect the offices of the Superintendent, Trigonometrical Surveys, and the Superintendent, Forest Surveys, at Dehra Dún. He reached Simla on 30th April, and during his stay there,

inspected the recess office of No. 18 Party on several occasions. He left Simla on the 16th July and arrived at Dehra the following day, and again inspected the offices of, and discussed various questions with, the Superintendent, Trigonometrical Surveys, and the Superintendent, Forest Surveys, finally re-arranging the programme of the Forest Surveys. On the 21st July, he proceeded to Mussooree and inspected the offices of Nos. 14 and 15 Parties, the North-West Frontier drawing office and the parties under the administration of the Deputy Surveyor General and Superintendent, Trigonometrical Surveys, located in that station. On the 6th August, he returned to Dehra and next day proceeded to Naini Tal where he inspected the office of the Superintendent, Provincial Surveys, United Provinces, and the drawing office located there, and returned to Calcutta on the 15th August. He had intended going to Bangalore and Poona to inspect the various survey parties and drawing offices at those stations, but was compelled to abandon this trip and to return to Simla on the 24th September to settle the programme of riverain surveys in the Punjab, in consultation with the Local Government and to discuss various other matters with the Government of India.

7. Colonel J. R. Hobday, I.A., Deputy Surveyor General, left Calcutta on 11th October for Nagpur to discuss survey matters with Mr. Sly, Settlement Commissioner, Central Provinces. He then proceeded to Saugor to inspect No. 1 Party in the field, and thence to No. 14 Party at Cawnpore, returning to Calcutta on 25th October. On 7th February, he proceeded to Burma to inspect Nos. 3 and 7 Parties in the field at Prome and Shwebo. He also interviewed the Settlement Commissioner at Kyauksè, and the Revenue Secretary at Rangoon, and returned to Calcutta on the 10th of March. On 17th May, he visited Darjeeling to attend a meeting of the Bengal Board of Revenue to discuss the question of forming 3 survey parties in that Province in lieu of the numerous detachments, and also to frame rules regarding the preservation of village trijunction marks. He returned to Calcutta on the 31st May. On 8th June, he proceeded to Simla to discuss with the Surveyor General various questions regarding the organisation of the department, and the work connected with No. 18 Party, and returned to Calcutta on the 7th July. On 16th July, he proceeded to Dehra and from thence on the 20th to Mussooree, where he accompanied the Surveyor General in inspecting the offices of the several survey parties recessing there. From Mussooree, he accompanied the Surveyor General to Naini Tal and inspected the United Provinces drawing office, and returned to Calcutta on the 15th August. On 28th August, he proceeded to Rajahmundry to inspect the Godávari detachment, and from thence to Bangalore where he organised the Training School, and inspected Nos. 3, 10, 11, and 19 Parties and the Bangalore drawing office. On the 27th September, he continued on to Poona where he inspected No. 17 Party, and from thence to Amráoti in Berar, where he visited No. 2 Party, which had just been formed, and finally returned to Calcutta on 8th October. During the year under report he visited the Bengal drawing office in Calcutta on several occasions.

8. Major S. G. Burrard, R.E., Superintendent, Trigonometrical Surveys, visited Kurrachee in April 1904, and inspected No. 12 Party; in June he inspected No. 22 Party; visited Mussooree in August and September and inspected Nos. 23, 24 and 26 Parties and the levelling detachment of No. 25 Party. He inspected in Dehra Dún No. 25 Party and the Survey Training School during the year from time to time.

9. Major Symonds, I.A., Officiating Superintendent, Forest Surveys, inspected the detachments of No. 9 Party working in Assam, Burma and Bengal, and No. 20 Party in the field. He also inspected the recess offices of No. 17 Party at Poona, No. 19 Party at Bangalore, and No. 20 Party at Dehra Dún.

DISTRIBUTION OF FIELD PARTIES.

10. During the year under report the double parties were separated. The parties formerly known as Nos. 2 and 8 and Nos. 9 and 19 are now designated Nos. 8 and 19, respectively. A new party, No. 2, working in Berar has been formed for the training of junior Imperial and Provincial officers, whilst scattered detachments employed on Forest Surveys have been amalgamated to form No. 9 Party. In Bengal the several detachments employed on cadastral and traverse

survey operations will next year be combined to form Nos. 5 and 6 Parties. The designation of Nos. 11 and 21 Parties has also been changed to No. 11 Party.

Field operations were carried on by 20 parties and 8 detachments; of these 8 were employed on topographical surveys, 4 on forest surveys, 3 parties and 8 detachments on cadastral and traverse surveys, 1 on triangulation and 4 on scientific operations.

In the following statement the whole of the operations are grouped according to the nature of the work on which the parties are employed:—

No. of Party.	Nature and <i>locale</i> of operations.	Page in this Report.	Executive Officers.	Scale of Survey.	Administrative Superintendent.
<i>Topographical.</i>					
1	Central Provinces . . .	19	Mr. R. C. D. Ewing . . . Captain A. H. B. Hume, R.E. . .	Inch. Miles. 2 = 1	D. S. G.
3	Lower Burma . . .	20	Mr. E. F. Litchfield . . . " P. J. Doran . . .	1 = 1	Ditto.
10	Upper Burma . . .	21	Captain F. W. Pirrie, I.A. . . Lieutenant A. A. McHarg, R.E. . . Major J. M. Burn, R.E. . . Captain C. P. Gunter, R.E. . .	1 = 1	Ditto.
11	Ditto . . .	22	Major J. M. Burn, R.E. . . Captain C. P. Gunter, R.E. . . Mr. P. J. Doran . . .	1 = 1	S. G.
12	Sind . . .	23	Mr. C. F. Erskine . . . Lieutenant E. T. Rich, R.E. . . Mr. G. G. Vander-Beek . . .	2 = 1	Supdt., Trig.
14	United Provinces . . .	24	Major C. W. H. Symonds, I.A. . . Captain H. L. Crosthwait, R.E. . .	2 = 1	S. G.
15	North-West Frontier . . .	25	Captain F. W. Pirrie, I.A. . . Mr. E. A. Wainright . . .	Various	S. G.
18	Punjab . . .	26	Captain E. A. Tandy, R.E. . .	Do.	S. G.
<i>Forests.</i>					
9	Bengal . . . Assam . . . Punjab . . . North-West Frontier . . . United Provinces . . . Central Provinces . . . Burma . . .	28	Major P. J. Gordon, I.A. . . " C. W. H. Symonds, I.A. . .	4 = 1	
17	Bombay Presidency . . .	29	Mr. B. G. Gilbert-Cooper . . .	4 = 1 8 = 1	Supdt., Forest Surveys
19	Madras . . .	31	Captain C. L. Robertson, R.E. . . Mr. G. T. Hall . . .	4 = 1	
20	Burma . . .	33	Captain A. Mears, I.A. . .	4 = 1	
<i>Cadastral and Traverse.</i>					
4	Bengal and 6 detachments . . .	35	Major R. T. Crichton, I.A. . . Captain F. C. Hirst, I.A. . .	16 = 1	D. S. G.
7	Burma . . .	40	Lieutenant-Colonel G. B. Hodgson, I.A. . . Captain C. P. Gunter, R.E. . .	16 = 1	Ditto.
8	United Provinces . . .	42	Captain W. M. Coldstream, R.E. . .	16 = 1	Ditto.
	Godávari detachment . . .	45	Mr. S. F. Norman, (Jr.) . . .	16 = 1	Ditto.
	Assam detachment . . .	46	" T. Shaw . . .	.....	Ditto.
<i>Trigonometrical.</i>					
24	India (Triangulation) . . .	47	Captain H. Wood, R.E. . . " H. H. Turner, R.E. . .	.....	Supdt., Trig.
<i>Scientific.</i>					
22	India (Latitudes) . . .	48	Major S. G. Burrard, R.E. . . Captain H. M. Cowie, R.E. . .	.....	Ditto.
23	Do. (Pendulums) . . .	49	Major G. P. Lenox-Conyngham, R.E. . .	.....	Ditto.
25	Do. (Tidal and Levelling) . . .	51	Captain H. H. Turner, R.E. . .	.....	Ditto.
26	Do. (Magnetic) . . .	53	Captain H. A. D. Fraser, R.E. . . Lieutenant R. H. Thomas, R.E. . .	.....	Ditto.

OUTTURN.

11. The total outturn of detail survey during the year amounts to 58,464 square miles, which includes 24,100 square miles of geographical surveys. The area surveyed during the previous year amounted to 70,797 square miles which included a geographical survey of 38,000 square miles. The total area triangulated is 22,496 square miles against 15,223 last year. The total area traversed for cadastral purpose is 8,720 square miles *viz.*, 3,181 square miles in the United Provinces, 4,545 square miles in Bengal, 859 square miles in Burma and 135 square miles in Madras.

TOPOGRAPHICAL SURVEYS.

12. During the year under report no changes of the *locale* of operations of the topographical survey parties have taken place, the work being carried on in continuation of that of previous seasons.

13. *Punjab*.—No. 18 Party continued the supplementary surveys in the Province, on the 2-inch scale, utilising and verifying the detail as obtained from reductions of the *patwári* village maps. An area of 2,669 square miles was thus completed in Multán district, and 421 square miles in Amritsar.

The progress of these much needed surveys was considerably hampered and curtailed, owing to the necessity for carrying on riverain surveys for the Local Government; also a portion of the staff of this party was engaged in completing and mapping the large scale survey of Simla. Similar supplementary surveys are urgently needed in districts Gurdáspur, Gujránwála, Siálkot, Gujrát, Shahpur, Jhang, and Muzaffargarh, and unless another survey party is shortly sent to the Punjab, it will be impossible to bring out topographical maps of this vast area, within a reasonable period.

14. *United Provinces of Agra and Oudh*.—No. 14 Party topographically surveyed on the 2-inch scale, an area of 1,936 square miles in districts Allahabad, Fatehpur, and Cawnpore, and 285 square miles of supplementary survey in districts Partabgarh and Rae Bareli to complete standard sheets up to graticule limits.

15. *Central Provinces*.—No. 1 Party completed the supplementary topographical survey on the 2-inch scale of an area of 2,839 square miles in districts Saugor and Damoh, including a forest area of 526 square miles which had been previously surveyed on the 4-inch scale, and which material was utilised and incorporated. A small area of 35 square miles in Gwalior, Bhopal and Panna falling in the standard sheets, was also surveyed.

An area of 1,722 square miles was triangulated in Berar, the detail survey of which will be commenced next field season, by a new party that will be formed for the training of junior Imperial and Provincial officers.

16. *Sind*.—An area of 2,715 square miles was topographically surveyed on the 2-inch scale by No. 12 Party in this Province.

17. *Baluchistan*.—An area of 1,287 square miles was topographically surveyed by No. 15 Party.

18. *Burma*.—An area of 2,148 square miles of topographical survey on the 1-inch scale was completed by No. 3 Party in districts Thayetmyo, Magwe, and Minbu, and 455 square miles of supplementary survey of such parts as had been previously cadastrally surveyed.

An area of 2,704 square miles of supplementary survey on the 1-inch scale was completed by No. 10 Party in districts Shwebo, Sagaing and Lower Chindwin, and 301 square miles of new topographical survey.

An area of 3,153 square miles of topographical survey on the 1-inch scale was executed by No. 11 Party in the Shan States of Nonglün, Kēng Tung, and Möng Pan.

19. The total outturn for the year under the head of new topographical survey and supplementary survey on the 1-inch and 2-inch scales, amounts to 20,948 square miles as follows:—

	Square miles.
Punjab	3,090
United Provinces	2,221
Central Provinces	2,839
Gwalior, Bhopal and Panna	35
Sind	2,715
Baluchistan	1,287
Burma	8,761

FOREST SURVEYS.

20. The forest survey operations during the year were generally in continuation of those of the previous season, and were under the administrative charge of the Superintendent of Forest Surveys.

21. In Madras No. 19 Party continued the detail survey on the 4-inch scale of the forests in the Godávari, Kistna, South Canara, and Kurnool districts, and the 4-inch revision survey in North Coimbatore. Triangulation was also carried out in Godávari, Chingleput, Trichinopoli, South Canara and North Malabar.

An area of 803 square miles was surveyed on the 4-inch scale at a cost of R102 per square mile, as compared with an area of 1,411 square miles at R58 per square mile in 1902-03. The increase in the rate is regrettable but unavoidable, owing to the very unhealthy season throughout the Presidency, more especially in the Godávari district where the entire camp lost a month's outturn through sickness. In South Canara the forests were mostly in detached blocks, which always entails loss of time and area. In addition to the above-mentioned causes labour difficulties, floods, want of water, and the extremely difficult nature of the country under survey, combined to affect the outturn, and hence the cost-rates, in an adverse manner. There was also a considerable increase in the pay of the executive officer during the year.

22. In Bombay, forest surveys on the 4 and 8-inch scales were carried out in the Násik, Khándesh, Sátára and Thána districts. A survey of Mátherán hill station on the 16-inch scale was also completed.

Six hundred and seventy-seven square miles were triangulated and 576 square miles topographically surveyed on the 4-inch, and 158 on the 8-inch scale, as compared with 487 and 240 in 1902-03. The cost-rates were slightly higher than for the previous season, being R67 and R139 for 4-inch and 8-inch detail survey as compared with R61 and R130 in 1902-03.

The season, as in Madras, was unhealthy and there was much sickness among all ranks. The necessity for moving the camps from the healthier districts, where they are employed at the commencement of the season, to the less healthy districts in the hot weather helps to add to the cost. The fact of two of the best surveyors of the party having been employed on the survey of Mátherán for nearly the whole of the season affected the outturn and, therefore, the cost-rates of the forest work. The increase, however, is a small one.

23. In Burma an area of 671 square miles was surveyed on the 4-inch scale by No. 20 Party in the Upper and Lower Chindwin, Pakókku, and Thayetmyo districts. A large area was also triangulated and traversed in advance in the same districts. The cost-rates were practically the same as for last year, being R44 per linear mile for traversing, and R136 for 4-inch detail survey. The cost of triangulation was R7·4 as compared with R3·2, per square mile. Compared by the fairest test, i.e., the number of stations of observation, the rate for this current season is more favourable than for last year. The rate for detail survey remains high owing to the difficult nature of the country under survey, and to the large expenditure in connection with the transport of the party from India to the Chindwin valley, and the unproductive time occupied on the journey.

24. The forest survey detachments, now known as No. 9 Party, were employed in Burma, Assam, Bengal, the United Provinces and the Punjab.

Two detachments working in the Mandalay, Katha, Shwebo, and Ruby Mines districts surveyed an area of 447 square miles on the 4-inch scale at a cost-rate of R91 per square mile, as compared with R64 in 1902-03. An area of 800 square miles was triangulated and 1,159 linear miles were traversed in advance; the cost-rates were R9 per square mile for triangulation, and R13 per linear mile for traversing, as compared with R10 and R37 respectively in 1902-03. The decrease in cost-rates for traversing and the increase in those of detail survey, are due entirely to the nature of the country under survey. As already explained in former reports, the cost-rates of these detachments cannot well be compared with those of No. 20 Party, the conditions being dissimilar.

In Assam, a detachment was employed in the survey of the forests in the Gáro hills, Kámrup and Nowgong; nearly 1,000 square miles were triangulated, 286 linear miles traversed, and 160 square miles surveyed on the 4-inch scale. The rates of all classes of survey in Assam were considerably reduced, that of detail survey being R85 as compared with R98 in 1902-03.

Considering the difficulties in connection with labour and transport, the flooded tracts encountered in the area surveyed, and the cost of transporting the detachment to and from the field, the results may be considered satisfactory.

In Bengal, besides triangulation and traversing, 219 square miles were surveyed on the 4-inch scale in Darjeeling and Kalimpong, and 91 square miles in Singhbhum, completing the surveys in these districts. The cost-rates were practically the same as for last year.

In addition to the operations detailed above small detachments were employed on the outline survey of the Jhelum and Lahore forests, the completion of the survey of the Naini Tal reserves, and on preliminary triangulation in the Hazára district.

25. The total outturn of forest surveys on various scales during the year amounts to 3,375 square miles.

Nearly two-thirds of the total gazetted forest area in India or 62,533 square miles, have now been surveyed on the 4-inch and larger scales for forest purposes.

CADASTRAL AND TRAVERSE SURVEYS.

26. During the year under report there was one cadastral party in the United Provinces of Agra and Oudh, one in Bengal with 6 detachments, one in Burma and one small detachment in Madras.

27. In the United Provinces 270 square miles were traversed in the Moradabad district, and 507 square miles surveyed cadastrally with records in the Amroha, Moradabad and Thákurdwára *tahsils* of the same district. The old cadastral maps and records were corrected in the Amroha *tahsil* of Moradabad, in the Báná and Pailáni *tahsil* of Báná, and in the Hamírpur, Sumerpur and Maudha *parganas* of Hamírpur, covering an area of 1,488 square miles. The following towns were surveyed for municipalities :—Muttra, Brindaban, Tánda Khas, Barehta (Fyzabad). In the two former, the open ground was surveyed on the 16-inch scale, but in the others the whole area was done on the 64-inch scale.

Surveys on the scale of 64 inches = 1 mile, showing the boundaries and adjacent detail of 1,125 linear miles of 1st class roads in the Meerut and Lucknow divisions, were carried out for the Public Works Department.

No. 14 Party also demarcated and traversed 2,911 square miles in districts Fatehpur and Cawnpore.

28. In Bengal 5,028 square miles were traversed, 4,054 square miles were surveyed cadastrally, and the records were written of 4,065 square miles in the Midnapore, Bhágalpur, Purnea, Backergunge, Ranchi and Singhbhum districts. An area of 463 square miles of the beds of the Ganges and Kosi rivers, was surveyed topographically on the scale of 4 inches to the mile. The survey of the suburbs of Calcutta was continued in conjunction with that of the Panchannagram Government estate and also those of the municipalities of Bhágalpur, Monghyr and Roserha (Darbhanga).

29. In Burma, 859 square miles were traversed, and 818 square miles cadastrally surveyed in the Pakókku and Shwebo districts.

30. In the Central Provinces the traversing of Forest excisions and scattered villages for local agency survey was continued. The area traversed is 41 square miles scattered over 5 districts.

31. In Assam, 91 square miles of tea grants were traversed, and 4 square miles for cadastral survey by local agency.

32. In Madras the survey of the Godávari delta for the Irrigation Department was completed, the outturn during the season being 135 square miles of traversing, cadastral survey and record-writing.

33. The total areas traversed and cadastrally surveyed are as follows :—

Province.	Traversing, Square miles.	Cadastral survey, Square miles.
United Provinces.	3,200	2,000 (a)
Bengal	5,028	4,054
Burma	859	818
Central Provinces	41	...
Assam	95	...
Madras	135	135
TOTAL	9,358	7,007

(a) Includes 1,488 square miles of map correction, and 5 of town surveys.

TRIGONOMETRICAL SURVEYS.

34. The programme of the triangulation party (No. 24) was to continue the Great Salween series southwards, but this was interfered with by the deputation of Captain Wood, R.E., to Nepal to investigate the identity of Mount Everest with a peak called Gaurisankar. When he returned in December, the season for observation in Burma was so far advanced that it was considered advisable to alter the programme and employ Captain Wood in observing geodetic azimuths at some of the longitude stations in India and Burma. The Provincial officers of the party were engaged during the field season in building stations for the Great Salween series extending as far south as latitude $20^{\circ} 30'$.

SPECIAL OPERATIONS.

35. Captain Wood was employed at the commencement of the field season in identifying the Himalyan peaks seen from Kátmánu. By the time that he had completed this important work, it was too late for him to commence trigonometrical operations in Burma, and as no other officer was available, the principal triangulation of Burma was not continued. Work on the Great Salween series of principal triangulation will, however, be resumed as soon as opportunity offers, as it is required to determine the terrestrial position of the eastern boundary of Burma.

36. On finishing his work in Nepal, Captain Wood with No. 24 Party, proceeded to observe rigorous astronomical azimuths at longitude stations in India and Burma. These azimuthal observations are required for the determination, by means of Laplace's equation, of the errors accumulated in the principal triangulation.

37. Captain Cowie in charge of No. 22 Party, extended the triangulation of the Great Arc of India northwards for a distance of 35 miles into the hills, and observed for latitude at stations in the heart of the Himalayas.

38. Pendulum observations were commenced this year with a new apparatus, and their progress is being watched with interest by European geodesists. The International Conference that met at Copenhagen in 1903, discussed the questions which were raised in the Survey of India Professional Paper No. 5 of 1901, concerning the deflections of gravity in northern and central India, and passed a resolution on the subject to the effect that the Indian plumb line determinations required to be supplemented by new observations of the pendulum, and that in no other way could the deformations of the geoid and the variations in the density of the earth's crust be definitely measured. After studying the use of the instrument at Potsdam, and observing with it at Kew and Greenwich, Major Lenox-Conyngham brought the new pendulum apparatus to India, and commenced determinations of the force of gravity in this country.

39. Tidal operations were continued by No. 25 Party, observations being recorded at 12 stations. The observatory at Okha in Cutch was opened during the year. Levelling operations were extended in Upper Burma.

40. Five detachments of No. 26 Party continued and extended the field work of the magnetic survey over different portions of the country. Four of the five base stations are now working, and it is hoped that Toungoo, the fifth, will be installed during 1904-05.

GEOGRAPHICAL SURVEYS.

41. Under this head are included surveys and reconnaissances which are executed on the $\frac{1}{2}$ -inch and smaller scales.

The survey detachment with the Aden Boundary Mission completed an area of 3,600 square miles on the $\frac{1}{2}$ -inch scale, and 2,500 square miles on the $\frac{1}{4}$ -inch scale. A narrative report of this work from the date of its commencement in 1901, will be found in the appendix.

The survey detachment with the Seistan Mission also completed about 15,000 square miles on the $\frac{1}{4}$ -inch scale during the year 1904.

Another detachment accompanied the Tibet Mission, and completed an area of about 18,000 square miles of the country between British territory and Lha-sa. Captains Ryder and Wood, R.E., also returned from Gyang-tse via

Shi-ga-tse and Gartok to Simla and added another 40,000 square miles of geographic survey of much interest.

HEAD-QUARTERS OFFICES, CALCUTTA.

42. The general direction of these offices remained under Colonel St. G. C. Gore, C.S.I., R.E., up to 23rd February 1904, and thereafter under Lieutenant-Colonel F. B. Longe, R.E. The Deputy Surveyor General's Office was also located, as usual, in Calcutta. The Surveyor General's Office was under Major J. M. Burn, R.E., up to 5th June 1904, and thereafter under Bt.-Lieutenant-Colonel T. F. B. Renny-Tailyour, R.E. The Drawing, Engraving and Map Record and Issue offices were under Major J. M. Fleming, up to 14th April 1904, when he proceeded on leave, and Major W. J. Bythell, R.E., took charge from the 3rd May 1904. The Photo-Litho Office was under Mr. T. A. Pope throughout the year. The Mathematical Instrument Office was under Major J. M. Burn, R.E., up to 5th June 1904, and thereafter under Bt.-Lt-Colonel T. F. B. Renny-Tailyour, R.E. Lieutenant C. M. Browne, D.S.O., R.E., remained attached to the Mathematical Instrument Office up to 31st July 1904.

43. *Drawing Office*.—The "General Section" has, as usual, been engaged throughout the year on the compilation and revision of the "general" maps, and the addition of new material to all standard sheets of which reprints and new editions are required. A large number of sheets received for publication from the various field parties have been scrutinized and prepared for press.

Ten "general" maps of India, on scales varying from 32 miles to 256 miles to the inch, have been in progress during the year, of which 5 are new editions. Of these the new 32 and 64 mile maps have been delayed for a very considerable period, owing to the difficulty of obtaining the correct alignment of boundaries of the North-West Frontier Province from the local authorities. These boundaries can only be considered as approximate, as they are not from actual survey.

Sixteen sheets of $\frac{1}{1,000,000}$ "map of India and adjacent countries" have been in hand during the year, and 13 of these are under publication.

Thirty maps of Provinces, chiefly on the scale of 16 miles=1 inch, have been in progress during the year, of which those of Bengal, Madras and Bombay are new publications.

Forty-four "District" maps on the $\frac{1}{4}$ -inch scale have been brought up to date or completed, 20 of which have been published.

Two hundred and thirty-six "standard sheets" on the scale of 1 inch=1 mile have been in hand. Of these 97 have been published, (29 being new publications and 27 new editions). Forty-four more are under publication, 2 are of the Andamans, 14 of Bengal, (of which 4 have been drawn in this office), 28 of Bombay, 31 of Burma, 72 of Central India and Rájputána, 4 of the Central Provinces, 8 of Madras, 6 of the North-East Frontier, 2 of the Northern Trans-Frontier, 46 of the North-West Trans-Frontier, 1 of the Punjab, 6 of the South-East Frontier and 1 of South-West Asia. The remarks contained in last year's report concerning the difficulty of reconciling these separate surveys when compiling new standard sheets still hold good.

Twelve Burma "Forest" maps have been brought up to date and published.

Twenty-one "Administration Report" maps have been brought up to date and published, 2 are in hand and 3 under publication.

Four of the Burma "Degree sheets" on the scale of 1 inch=4 miles have been in hand during the year, 1 has been published, 2 are under publication, and 1 is under compilation.

Eighteen "Index" maps on various scales have been brought up to date and published, 4 triangulation charts are in hand, 1 is under publication and 4 have been published.

A large number of plans of cities and cantonments, aggregating 76 sheets, all on large scales of survey, have been dealt with: of these 14 sheets are in hand, and the remainder have been brought up to date and published.

44. In the "Colouring Section," 2,523 sheets have been coloured during the year.

The demands for "extra departmental" work have as usual been very large, entailing considerable delay in the legitimate work of the office, which is the compilation of, and bringing up to date of, the "general" and "standard" maps. It has been found impossible to deal with more than a small number of the standards as reprints of sheets out of stock, and these arrears continue to increase; nor will this state of affairs improve until either the staff is very materially increased, or the present staff is entirely relieved of all "extra departmental" work.

The large "Postal" maps of Provinces on the 8-mile and 4-mile scale, have taken up the time of 3 or 4 draftsmen continuously throughout the year. Of these the maps of Bengal and Berar have been completed and are under publication, whilst that of the United Provinces is in progress. In all some 101 sheets of purely "extra departmental" work have been dealt with.

45. In the "Examining Section," 3,068 sheets have been passed, and a large amount of "miscellaneous" work, such as the supply of data, examination of proofs, spelling, computation of graticules, etc., has been carried out, whilst the revision of the Gazetteer has involved much labour in the supplying of correct geographical positions of towns, villages, limits of fiscal divisions, lengths of rivers, etc.

46. In the "Revenue Section," 387 standard sheets have been dealt with. Of these, 148 in 430 sections are new sheets received from parties and sent for publication, the greater number being received from the Punjab and United Provinces parties. Of the total number of standard sheets dealt with, 137 were new publications, 51 new editions, and 199 reprints.

With a view to expediting the publication of Bengal standard sheets from the old fragmentary surveys, (a work much in arrears as few such sheets at present exist) sanction was accorded to the formation, for a year from 1st June, of a small "arrears section," consisting of 1 retired Provincial officer and 10 draftsmen. Owing to the impossibility of obtaining trained draftsmen on the low pay allowable in Calcutta, it was found necessary to entertain some of the unpaid apprentices then working in the Drawing Office. The progress of these youths is painfully slow. However, during the period, i.e., from 1st June to the close of the survey year, 13 standard sheets of Bengal have been taken up and are in various stages of progress, 2 having been sent to press. 6 sheets of Assam were also in hand, of which 4 have gone to press, and 1 of the Punjab is ready for press. It is hoped that, with increased experience, the work of this section will steadily improve both in quality and quantity.

The "special" maps to show the Nepal boundary along the Sárda river, mentioned in last year's Annual Report have been published, and the final proofs received from the Foreign Department have been sent for approval to the Nepal Durbar, but have not yet been received back.

The usual revision work has been carried out on "Index" maps, 1 new one having been prepared. 1,252 pages of traverse have been copied and examined to comply with various applications, and a very large amount of "miscellaneous" work, such as preparation of scales, calculation of areas, etc., has been done.

Eighty traces and copies of village plans were prepared for district officials, and the number of applications received for copies of maps etc., from private individuals amounted to 1,268, in response to which 2,154 authenticated copies were issued, the Government fees thereon amounting to Rs 1,264.

A total of 32,746 coloured copies of maps have been examined and passed, and 394 pairs of office copies have been prepared, examined and certified, whilst 716 more have received corrections and additions. The plan lately instituted of bringing all the office copies of maps into racks in one room and placing them all under charge of one Provincial officer, will, it is hoped, ensure their preservation, whilst their careful registering will greatly lighten the labour of searching for them when required for reference.

47. *Engraving Office.*—The outturn of work completed by this office is slightly in excess of last year's. 4 new quarter sheets of the Atlas of India Nos. 41 N.-E., 41 S.-E., 50 S.-W. and 78 S.-E., and 2 district maps Wun, Central Provinces and Kámrúp, Assam, on the 8-mile scale, have been published.

A new map of India on the 32-mile scale has been commenced, 2 sheets having been projected and sent for compilation. It has been decided to

complete this map in outline and writing on one set of plates, the hills being engraved on a second set for double printing. The new map on the 64-mile-scale is still under compilation. The duplicate plates of the map on this scale have been pushed on as fast as possible, sheet 1 is completed in outline and writing and also sheet 2, the latter being in the hill etchers hands; sheet 4 has only a small portion in the north-west corner to complete it in outline and writing. The heavy corrections necessary to bring the 80-mile railway map up to date have been carried out and a transfer sent to the Photo. Office. The general map, on the same scale, in 2 sheets, is in hand with heavy corrections, to bring it up to date. The new material on the frontiers on the 96-mile map, has been completed and the internal portion is being brought up to date. Both the maps on the 128-mile scale are being brought up to date and the new map, on this scale, which is intended to be used for "administration report" purposes has been completed in outline and the writing commenced. Slight corrections were carried out on the 192-mile map. Both the 256-mile maps, with and without hills, have been in hand with further additions and corrections. 3 new plates for the "Bay of Bengal" and "Bengal daily weather report" have been cut and 2 new "weather charts of India" are being engraved. 9 plates of "India and adjacent countries" on the $\frac{1}{1,000,000}$ -scale have been in hand, the Andaman Islands sheets being advanced in writing. Portions of the hills to one of these sheets have been engraved and registered in brown, with the outline and writing in black, and the process promises to be very successful.

Of the maps on the 16-mile scale the corrections on the map of Assam were stopped, as with so many changes, the condition of the present map does not warrant its being further worked upon when the sheets of the $\frac{1}{1,000,000}$ map will soon be available for this part of the country. The 2 sheets of Bengal are having the boundaries and district names cut upon them. Some new material has been cut on the map of the Bombay Presidency, but it still requires further material to complete it. The 2 sheets of Central India Agency have been brought up to date. The map of the Madras Presidency has been completed and is under examination. The map of the Punjab, in four sheets, was ready for publication with the exception of a few external boundaries, but further changes have taken place in the formation of new districts, which will necessitate further corrections to the plates before the map can be issued to the public.

Twenty-eight maps, for administration reports, and 3 index maps were brought up to date.

Sheets 2, 3 and 6 of the 16-inch plan of Calcutta, are being brought up-to date. The 6-inch plan has been completed with street names, where it is thought no change is likely to take place, and is now waiting for the list promised by the Municipal Corporation before proceeding further. A 3-inch plan has been put in the hands of the engravers and is well advanced in outline.

Fifty-six new "quarter Atlas sheets," in various stages of progress, were added to; 124 published "quarter sheets," and 29 full sheets have been in hand to bring them up to date before printing, whilst 24 new "quarter sheets" have been projected or had borders cut on them.

Fifty-three miscellaneous plates of scales, conventional signs, and tints for heliogravure have been cut or had titles and foot-notes cut upon them, making a total of 364 plates that have been worked upon during the year.

The three new copper-plate printing presses were in working order by the end of February, and this section has now been placed on a footing able to cope with the demand for engraved maps. It is already beginning to relieve the pressure of demand for maps, but will take some time yet to put the Map Record and Issue office in possession of copies from all the engraved published coppers. The result of the increased number of presses has been an outturn of 47,720 copies. The large number of plates required by this section has put much more work on the "steel facing section" which had to deal with no less than 450 plates.

Twenty-seven plates were corrected and filled in by electro-deposition and the grey effect produced by the silvering process has been overcome, the plates now treated being clean after deposition.

48. *Photographic and Lithographic Office.*—The total outturn of printed copies of maps, plans and diagrams, both for the Survey of India and for other-

departments, shows a slight falling off as compared with last year's results, the small difference being accounted for by a considerable reduction in the number of cadastral sheets received for reproduction from Burma. Last year the total number of copies printed both from zinc and stone in the lithographic machines and presses, amounted to 1,032,495. During the year under report the total number was 968,145, or 64,350 less, and it comprises 250,530 copies of departmental maps, as against 186,609 last year; 54,340 copies of cadastral maps, as against 126,203; and 663,275 copies of maps, plans, etc., done for other departments, as against 719,683. It will thus be seen that the decrease in the number of cadastral sheets printed, amounting to 71,863, more than accounts for the total decrease of 64,350 shown under all three heads. The amount of work done for the Survey of India has, it will be seen, increased considerably, while there is a corresponding reduction in the amount done for "extra-departmental" purposes. This result, however, is not due to any reduction in the demands made upon the office by other departments, but to the fact that such work has, in many instances, been declined in order that there should be no undue interference with the publication of departmental mapping. The year's working in the other sections of the office shows very satisfactory results, especially in the "heliogravure section," where the number of copies printed from photogravure-plates amounted to 86,447, or 25,449 more than last year. A much larger quantity of work was executed by the half tone block process, the number of blocks prepared being 94 or 77 more than last year, the number of copies printed from them being 39,249.

49. In para 54 of last year's report, reference was made to the necessity for more skilled European supervision in the sections engaged on the photo-zincographic reproduction of maps. Steps have now been taken to remedy this defect, the Government of India having applied to the Secretary of State for the services of two additional European assistants, one to be attached to the "zinc printing section" to relieve the head printer of the whole of the "extra-departmental" work which now occupies so much of his time, and the other to take charge of the "transfer printing section." It is hoped that these men can be obtained from the School of Military Engineering at Chatham, where instruction is given in photozincography and kindred processes to non-commissioned officers of the Royal Engineers, and that they will arrive early in 1905. From this much needed addition to the European supervising staff, it is expected that a decided improvement in the quality of the work turned out will result.

With regard to the quantity of work done, matters remain very much as they were a year ago, and it is still impossible for this office, with its present establishment and plant, to execute all the work demanded from it. If all the "extra-departmental" work received were to be put in hand at once, serious delay in the publication of the Survey of India maps would inevitably ensue. On the other hand, to give precedence in every case to the work of the Survey means, that the work required by other departments, almost always of an urgent nature, has to be taken up so late that it becomes useless for the purpose for which it is intended. These questions will be fully considered by the Survey Committee now sitting, and there can be little doubt that the only solution of them lies in the entire removal of the "extra-departmental" work to some other agency.

The block in the lithographic sections has been to some extent removed by the addition of four new posts for lithographic draftsmen, referred to in para 59 of last year's report, which has enabled the office to execute a larger amount of lithographic drawing for departmental purposes than in any previous year. In order to expedite work in the photographic branch of the office, the Assistant Surveyor General proposes to employ a system of electric illumination of the plan-boards in the "negative section," which he believes will reduce the time occupied in exposing the negatives very considerably, and so enable a larger number of negatives to be turned out daily, especially in dull rainy weather, when the work of the section is often at a standstill for want of light. Two pairs of powerful arc lamps, of the pattern used in England and America for the same purpose, have been included in the annual store indent of the office for 1905-06, and it is hoped that they will be installed before the rainy season of 1905 sets in.

50. In the "Photographic Branch" the following were the more important departmental publications of the year:—

- (1) A map of Persia, on the 16-mile scale, in 6 sheets, with hills in brown, photozincographed and 1,800 copies printed.
- (2) A map of Aden, on the 8-inch scale, in 6 sheets, with hills in brown, photozincographed and 1,800 copies printed.
- (3) Eight sheets of the new $\frac{1}{1,000,000}$ map of "India and adjacent countries," with hills in brown, photozincographed and proofs supplied.
- (4) A sketch map of part of Nepal, on the 16-inch scale, reproduced by the Vandyke process and 220 copies printed.
- (5) A map of Maymyo and surrounding country, on the 1-inch scale, with hills in brown, photozincographed and 300 copies printed.
- (6) 216 standard sheets on various scales, were either photozincographed or reprinted from old plates, of which 39 were in two colours. In addition to these, 16 standard sheets of the Central India and Rájputána survey were reprinted and 5,000 copies on cloth were supplied to the Director of Land Records, Gwalior State.

Among the many items of work executed for other departments either by photozincography or the Vandyke process, the following may be specially mentioned:—

For the Quarter Master General in India, a military traffic map of India, on the 80-mile scale, in two sheets and four colours, was reproduced by the Vandyke process, and 2,400 copies supplied. For the same officer, a district map of India, on the 64-mile scale, was photozincographed and 240 copies printed; and two maps of Korea and Manchuria, each in two sheets, were photozincographed and 1,770 copies supplied.

For the Post Master General, Central Provinces, a postal map of the Province, on the 18-mile scale, in 8 sheets, was photozincographed and a proof supplied.

For the Pakôkku Municipality a wall map of Pakôkku town, in two sheets, was photozincographed and 50 copies supplied.

For Mr. G. W. Forrest's "Selection of State Papers" dealing with the mutiny of 1857, five maps of the city and environs of Lucknow were photozincographed and 1,070 copies of each printed.

For the Linguistic Survey, one language map in four colours and another in three colours were photozincographed, and 1,335 copies of the former and 1,265 of the latter were printed.

In addition to the above a very large amount of miscellaneous work was done for the Public Works, Telegraph and other departments, and for the Military authorities, as usual, a large number of manœuvre maps, on various scales and chiefly in two colours, were either photozincographed or reprinted from existing plates.

51. In the "Lithographic Branch," work on the new 32-mile map of India proceeded continuously throughout the year. The drawing of the entire outline of the six sheets was completed, but a few additions and corrections have still to be made on sheets 3, 5 and 6. The drawing of four of the hill sheets, Nos. 2, 3, 5 and 6, is now complete. One more is in hand and will be completed early in 1905. The map of the Madras Presidency, on the 32-mile scale, which has been in hand, off and on, since 1901, was completed and printed in February 1904. The map of the Rájputána Agency, on the 16-mile scale, was also completed and printed in the same month. Work was continued on the two maps of Bengal, Bihar, Orissa and Chota Nagpur, on the 32-mile and 16-mile scales, respectively, on which heavy additions have to be made to the stones. 59 district maps, prepared from copper-plate transfers from Atlas sheets, were dealt with during the year, of which 26 were in hand at the close of the previous year. 19 of these were printed; proofs of 27 more were sent to the "drawing office," and 13 are still in progress.

The work done by lithography for other departments was as usual of great variety, and quite half the staff of litho draftsmen was engaged upon it throughout the year. The following are the more important items:—

The remaining three sheets of the new Telegraph map of India on the 32 inches = 1 mile scale, were completed and proofs despatched early in the year.

All six sheets have since been returned with corrections, and these have been carried out and a second proof of the map supplied. Four large maps were prepared from copper-plate transfers for the Inspector General, Army Remount Department—one in nine sheets, one in four, one in two and one in a single sheet. These were all completed and proofs supplied, which have been returned with many corrections involving the entire re-doing of at least one of the maps. For the Linguistic Survey, 14 language maps were prepared, all of them in several colours, and five of them were printed. An irrigation map of the Punjab, in four sheets and five colours, was in hand during the year and was nearly completed at its close. Heavy corrections were made to another Irrigation map of the United Provinces. For the General Officer Commanding the Forces, Bombay, five large maps of Karachi, Hyderabad and Jacobabad cantonments, Ghizni sanitarium and Karachi rest-camp were prepared and printed. For the Traffic Superintendent, North Western Railway, a map of that railway and connected lines in black and two colours, was prepared and 10,000 copies were printed. For the United Provinces Government, a map showing canals completed and proposed was prepared and proved, and is now having additions made to it. For the Foreign Department, 25 maps and diagrams were lithographed and copies in various numbers were supplied of all except one, which is still in hand. For the Government of India, Public Works Department, 38 plans and diagrams were lithographed, of which 25 have been completed and printed, the remainder still awaiting press order.

Just before the close of the year a new lithographic printing machine, by Messrs. Furnival & Co., was received on indent from England. It was erected early in September 1904, but was not in working order when the year closed, owing to unavoidable delay in attaching the electric motor by which it will be driven. It is slightly larger than our present largest machine, and will be a valuable addition to our printing power. It is intended to utilise it exclusively on departmental work, principally standard sheets. With this new machine, and the improved methods referred to in para 49 about to be introduced in the "negative section," it is expected that the outturn of departmental work will show a considerable increase next year. The new electric motors, with one or two exceptions, gave no trouble. The motor attached to one of the type-printing machines broke down several times and caused much delay while it was being repaired, but it is now in good order. The change from steam to electric power has proved to be an unqualified success. There was not a single break of any importance in the continuity of the current during the year, and the motors, with the single exception already mentioned, have amply fulfilled all our expectations.

52. Map Record and Issue Office.—The work in this office shows a very considerable increase on the returns for last year, except in the number of sheets issued. The purely clerical work, i. e., number of letters and invoices issued and received shows an average increase of over 25 per cent., and as the staff has not been increased, it has proved a matter of the greatest difficulty to keep pace with the demands.

Eighty-six thousand, four hundred and eighty-nine sheets of an aggregate value of Rs 1,04,098 were issued during the year, and of this total a sum of Rs 16,223 was realized from private sales. As reported last year no further despatches of printed cadastral maps were made and the falling off both in number and value of the issues as compared with the return for last year, may again be considered as due to this cause.

The number of new maps received for publication was 142, whilst 528 were published, of which 336 were reprints. The number of original maps, volumes of records, etc., issued from store to other departments amounted to 7,983, of which 4,403 were received back again.

The transferring of the original cadastral sheets from this office to the various head-quarters of Local Governments or districts, has been carried on steadily throughout the year. Those of districts in the United Provinces of Agra and Oudh, of 9 districts in Burma, of 18 in Bengal and of 3 in Assam, making a total of 55,265 sheets, were despatched from the office during the year, and it is hoped that this work will be completed by the end of next year.

The transfer of the large scale forest maps to the Office of the Superintendent, Forest Surveys, Dehra Dün, has been continued, and a total of 11,731

copies of 278 maps of the Burma forests has been despatched during the year. This work is in abeyance at present as the accommodation at Dehra is not yet completed.

The work of revising the catalogues and bringing them up to date has also been steadily proceeded with. The catalogues of the sheets of the Atlas of India, of the maps and plans of Bengal, and of "India and adjacent countries" have been published, whilst those of the Punjab and United Provinces are well advanced, and the remainder will be prepared as expeditiously as possible.

With the work of revising the catalogues, advantage is also being taken of examining and re-arranging the printed sheets, but with a total of nearly four million such maps to deal with, comparatively little progress has been made with this most desirable work owing to the insufficiency of the staff. It is a work quite apart from the usual routine, and the establishment is not strong enough to allow of a few men being told off specially to carry it on continuously, as all hands are fully occupied in complying with current demands and in carrying on the clerical work.

Only 1,422 special maps were opened out and re-stored flat during the year. This number would have been largely exceeded, but for the fact that space for storing them depends on the rate of transfer of the forest maps to Dehra Dún, and as pointed out above, the rack accommodation for the latter at Dehra is not yet complete.

The improvement in the state of this office mentioned in paragraph 67 of last year's report, is steadily maintained and the credit is mainly due to the Head Clerk Mr. Rundlett and the Map Curator Mr. McCurley. The staff of the office have with one or two exceptions ably assisted the above officers.

53. Mathematical Instrument Office.—During the year under report, i.e. from 1st April 1903 to 31st March 1904, there has been a considerable increase in the demands made on this office. For each of the last three years the value of instruments, etc., issued was R2,72,976, R3,10,348 and R3,64,646, respectively, and the value of repairs to instruments returned for that purpose was R29,345, R32,242 and R37,449, respectively. The value of instruments returned "on deposit" during each of the last three years has remained fairly constant.

The book value of the stock in the "serviceable store in hand" at the end of each of the last three years was R5,13,547, R4,72,065 and R3,85,145, respectively. This result is satisfactory and is due to a considerable extent to the fact that, during the last two years, indents for instruments, etc., obtained from the Director General of Stores may be submitted piecemeal, while formerly only one large annual indent was permissible. It is of course dangerous to reduce this value too much, as some of the most valuable instruments take a considerable time to manufacture, and it is necessary to be prepared to meet the demands of Government officers within a reasonable time, even when the indents are unexpected and large.

The book value of the stock in the "repairable store in hand" at the end of each of the three last years was R2,30,155, R1,80,999 and R1,64,474, respectively. This result is also satisfactory, the principal cause of the reduction in value being on account of instruments which had been lying for a considerable number of years in this store, which have now been transferred to the "serviceable store," through the workshop. Further reductions by this means will be very small in future as the accumulation of instruments that could be profitably converted or repaired, is practically absorbed. The present stock consists mainly of more or less obsolete instruments, some of historic interest might with advantage be written off and placed in a museum, and others, although there is no regular demand for them at present, might possibly be required later on when they would be at once repaired and issued. As soon as it is evident that any of the instruments of this latter class are absolutely out of date and useless, they will be condemned.

The "profit and loss statement" for the workshop shows an increased profit. The number of men and boys employed at the end of each of the last three years was 205, 255 and 320, respectively. The piece work system has been further extended and has proved so beneficial that the increase in the value of the total outturn of work from the workshop has been considerable, the figure for each of the three last years being R1,12,865, R1,25,722 and R1,50,567, respectively.

The value of instruments, etc., manufactured in the workshop for the serviceable store during each of the last three years was Rs 33,427, Rs 47,729 and Rs 57,095, respectively, while the value of those purchased locally was Rs 17,793, Rs 13,329 and Rs 11,641, respectively. The continued increase in the former and decrease in the latter, are both very desirable results.

54. The value of instruments, materials, etc., obtained from the Director General of Stores during each of the last three years was Rs 1,06,008, Rs 1,01,594 and Rs 1,46,509, respectively. These amounts should naturally show a considerable increase owing to the large rise in the value of issues, but have been kept down by the reductions that have been made in the value of the stocks in both the serviceable and repairable stores. These reductions cannot possibly be expected to continue and, in spite of the fact that there are increases in the value of the instruments manufactured by the workshop for the "serviceable store," a very considerable increase in the value of the indents sent to England must be expected in future years.

A new two storied building was completed and occupied during the year and has proved extremely useful, the upper floor is principally used for polishing and lacquering and the lower floor for testing and examining instruments.

BRANCH OFFICES, DEHRA.

55. *Trigonometrical Surveys.*—The superintendence of the Trigonometrical Branch was in the hands of Mr. J. Eccles, M.A., up to the 3rd November 1903, on which date he was relieved by Major S. G. Burrard, F.R.S., R.E. During the absence of Major Burrard on furlough Mr. C. H. McA'Fee held charge of the technical offices.

The following papers were printed during the year and are ready for issue:—

1. A reprint of Professional Paper No. 5 on the attraction of the Himalayas on the plumb line in India.
2. Notes on the use of the Jäderin base line apparatus.

In addition to the above a 4th edition of the Auxiliary Tables was compiled and is now going through the press. A second edition of the Great Arc Meridional series, section 18° to 24°, and a revised rainfall pamphlet are also in the press.

Captain C. G. Rawling's and Sub-Surveyor Ram Singh's triangulation in Western Tibet, and Surveyor Mohammad Zakaria's traverse of the Hardwár-Dehra Dún railway line, were computed. Considerable progress has been made in the reduction of Mr. Barckley's snow peak triangulation, and Colonel Tanner's triangulation has also been taken in hand. Messrs. Serrao's and Jarbo's triangulation in Burma was examined and adjusted.

Data were supplied to 43 officers, and the comparison of press proofs was carried on as usual.

Two officers Lieutenants R. H. Phillimore, R.E., and H. S. May, R.E., were put through a course of trigonometrical, topographical and astronomical work, and five sub-assistants of the Provincial service went through a course of topographical surveying, traversing and mapping.

In the drawing section a special map of the country surveyed by Captain C. G. Rawling and Sub-Surveyor Ram Singh was prepared and printed. The railway line from Hardwár to Dehra Dún was plotted on the 4-inch standard sheets.

Seven triangulation charts and four standard sheets on the 1-inch scale, of Dehra Dún and adjoining districts, have been put in hand and are well advanced. Four maps of India and adjacent countries on the scale of 1 to 1,000,000 were taken up, but owing to press of work these had to be put aside very often and have not advanced so much as they should have.

A map of the Province of Ssu-Chuan in China has been compiled for the Quarter Master General, Intelligence Branch, and is nearing completion.

A map of the country five miles round Chandigarh on the 2-inch scale was prepared for the General Officer Commanding, Sirhind district.

The plotting of forest boundaries of the Hoshangabad district was completed, and 307 plots on the scale of 16 inches to a mile were supplied to the Deputy Commissioner, Hoshangabad.

Seven diagrams were drawn for the Superintendent, Trigonometrical Surveys, to illustrate a special report by him.

During a portion of the year a number of promising lads were trained to draw level sheets and to use the pantograph and from these 14 have been chosen and employed.

In the colouring section 2,200 maps were coloured.

In the photozinco section 864 maps, diagrams, etc., were photographed, against 889 during 1902-03, and 57,464 pulls taken as against 43,358 in the same period.

The compilation of the professional volume, giving the results of the spirit levelling in India has made good progress.

During the year 25 lines of levels extended over a distance of 4,040 miles, connecting 3,597 bench marks, were compiled and tabulated.

The photo-helio section carried on its work as usual.

56. *Forest Surveys*.—The offices of the Forest Survey Branch were under the superintendence of the Superintendent, Forest Surveys, and were employed as usual on correspondence and accounts, computations, area statements, the mapping of field surveys, the compilation of special working plans and other maps, the distribution of published maps, and the up-keep of the map records of the Forest Department.

During the year, 328 maps have been sent to press, and 293 have been published at Dehra Dún and Calcutta. These numbers do not include 111 maps of No. 17 Party which were published previously in the Bombay Government Photozinco Office, at Poona.

Nine thousand, seven hundred and sixty printed maps were issued, of which 5,840 were coloured and 3,704 were mounted in book forms.

During the year a sum of R247 was realised by the sale of maps but the demand for forest survey maps by the general public is not a large one.

Considerable progress has been made in the arrangement and storing of printed maps in a systematic manner in the Forest Survey Office.

A series of maps consisting of a map of India on the scale of 1 inch=32 miles showing the distribution of forest lands under the Government of India, a map showing the progress of forest surveys and working plans on the scale of 1 inch=48 miles, and of stock maps showing the distribution of the most valuable timber trees and the rainfall, were compiled by Mr. A. Descubes for the St. Louis Exhibition.

A series of lists of Forest survey maps of divisions, in which forest surveys have been completed, is under preparation.

LOCAL DRAWING OFFICES.

57. These continued the compilation of topographical maps at the following localities:—

58. *North-West Frontier Drawing Office, Mussooree*.—This office has been employed on the preparation of the maps of the Northern and North-West Frontier series, and South-West Asia series, in addition to which the hill shading of 4 sheets of the Khojak 6-inch survey, were drawn under instructions from the Quarter Master General's Department, for surprinting in red.

The following sheets were sent to press and subject to slight corrections by the Quarter Master General's Department, will shortly be published.

Northern Trans-Frontier series—

Sheet No. 2 S.E., (2nd edition) scale 1 inch=4 miles.

North-West Trans-Frontier series—

Sheet No. 7 N. W., scale 1 inch=4 miles.

" " 14 S. W. (3rd edition) scale 1 inch=4 miles.

" " 15 S. W. (Western half) (2nd edition) scale 1 inch=4 miles.

" " 21 S. W. (3rd edition) scale 1 inch=4 miles.

" " 29 S. W. (4th edition) scale 1 inch=4 miles.

South-West Asia series—

Sheet No. 72 (3rd edition) scale 1 inch=8 miles.

" " 73 " scale 1 inch=4 miles.

" " 73 N. E. " "

" " 73 S. E. " "

59. *Bangalore Drawing Office*.—This office continued the compilation of the "degree sheet" maps of Burma.

60. Local drawing offices at the following centres carried on as usual the compilation of 1-inch standard maps from cadastral surveys, *i.e.* one at Naini Tal in the United Provinces, one in Bengal at Calcutta, and a third in Assam at Shillong. The work done by these offices is contained in Part II of this Report.

ESTABLISHMENT.

61. During the year under report, Colonel St. G. C. Gore., C.S.I., R.E., vacated his civil appointment of Surveyor General of India. The following is an extract from Revenue and Agricultural Department letter No. 963—38-5, dated 12th July 1904, acknowledging the General Report for 1902-03.

"This report is the last to be prepared under the direction of Colonel St. G. C. Gore, C.S.I., R.E., late Surveyor General of India, who retired in February last from the service of Government after having served for more than 30 years in the Survey of India. Colonel Gore was appointed Surveyor General on 1st October 1899, and thus occupied for over four years the responsible position of head of the department. The Government of India desire to take this opportunity of placing on record their high appreciation of the services rendered by Colonel Gore as Surveyor General and of his efficient and successful administration of the department; and their good wishes go with him in his retirement."

62. In the Provincial service the department has lost the services of twelve officers during the year, *viz.*, by the retirement of Messrs. R. C. D. Ewing, E. A. Wainright, J. Hickie, W. J. Cornelius, J. R. Scott, G. E. Parker, P. J. Doran, J. C. Swiney, G. G. Vander-Beek and Munshi Imam Sharif, K. B., and by the death of Messrs. H. A. Gibson and F. O. Scott. Ten additional appointments were sanctioned during the year under Revenue and Agricultural Department No. 848, dated 23rd June 1904.

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

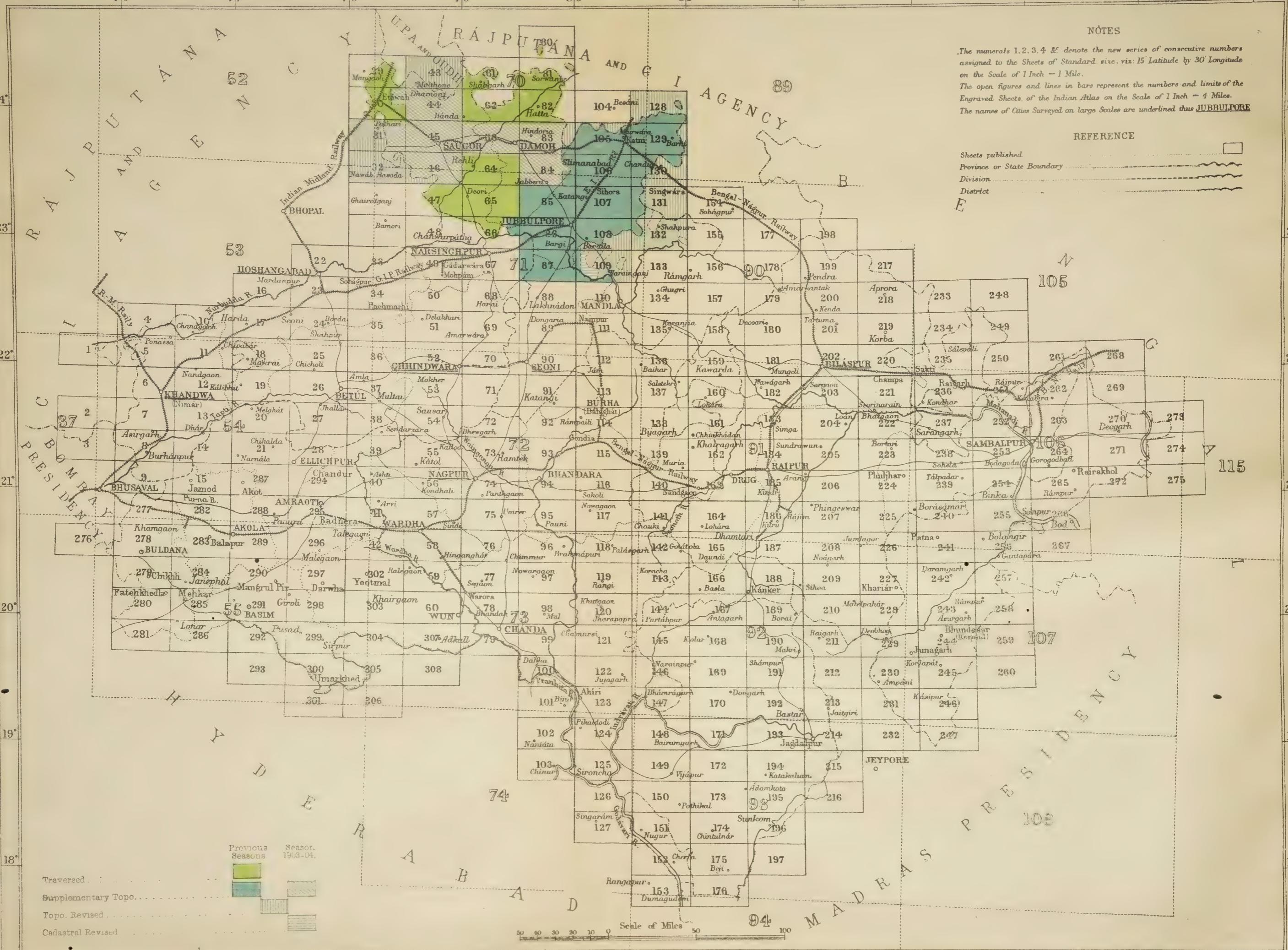
CENTRAL PROVINCES.

INDEX TO SURVEYS.

No. 1 PARTY.

1903-04.

76° 77° 78° 79° 80° 81° 82° 83° 84° 85° 86°



Previous Seasons
Traversed
Supplementary Topo.
Topo. Revised
Cadastral Revised

Scale of Miles

PART II.

THE OPERATIONS OF FIELD PARTIES.

TOPOGRAPHICAL SURVEYS.

CENTRAL PROVINCES.

NO. 1 PARTY.

Personnel.

Captain A. H. B. Hume, R.E., Officiating Deputy Superintendent 1st grade, in charge from 23rd November 1903.

Mr. R. C. D. Ewing, Extra Deputy Superintendent, 2nd grade, in charge up to 22nd November 1903.

Mr. B. M. Berrill, Sub-Assistant Superintendent, 2nd grade.

Munshi Ikbaldin K. S., " " 2nd "

Mr. F. C. Glass, " " 3rd "

20 Sub-surveyors, 8 computers, draftsmen, etc.

63. The Central Provinces detachment as it was then named, commenced field work at Saugor on the 16th October 1903. In March 1904, it was raised to the

status of a party and designated No. 1 Party. The operations comprised—

- (a) Traversing.
- (b) Supplementary topographical survey and mapping on the scale of 2 inches to a mile.
- (c) Revision survey.
- (d) Preparation of district maps.

64. *Traversing.*—The traversing was carried on of forest excisions and scattered villages of 5 different districts, as called for by the local authorities. One sub-surveyor was employed throughout the season and a second for 2 months. They traversed 48 village circuits comprising 180 linear miles or 41 square miles. Copies of the data, and 16-inch plots were sent to the several Settlement officers.

65. *Supplementary topographical survey.*—Two camps were employed on this survey each including 8 trained and 3 probationary sub-surveyors, under Mr. Berrill and Munshi Ikbaldin, respectively, and Mr. Glass was attached to Mr. Berrill's camp.

The area surveyed is :—

	Square miles.
District Saugor	1,841
" Damoh	998
State of Panna	2
Overlap Gwalior and Bhopal States	33
	2,874
Transferred to maps from reductions of forest surveys	526
	3,400

The work was tested by 1,079 *in situ* fixings and 280 miles of chaining, and 2,874 double value clinometric heights were observed, an average of one per square mile. A few heights were trigonometrically deduced, for areas where points with heights were deficient. The average daily outturn per man for working days was 0·84 square mile, and the monthly average 22 square miles.

The expenditure on supplementary topographical survey amounts to Rs 1,047 giving a cost-rate of Rs 10·8 per square mile, and the mapping of 3,400 square miles cost Rs 9,857 giving a further cost-rate of Rs 2·9 per square mile. The mapping of the above area, included in 9 standard sheets, is completed and ready to submit for publication. It was found this season that the details from the old 4-inch Revenue surveys that had been reduced and entered on the field sections, as mentioned in last year's report, were of no assistance but rather a hindrance, as in hilly ground the detail was quite inaccurate, and the face of the country has entirely changed as regards village sites, cart roads, foot-paths, tanks, etc. The reduced details of the main streams and boundaries from the 16-inch local agency maps were, however, found accurate and useful.

The field sections for next season's supplementary topographical survey of Saugor district have been prepared from reductions of the 16-inch maps and those of Narsinghpur district are being similarly prepared.

66. *Revision survey*.—In the outlying States, and portions of Mandla district falling in the standard sheets under survey, a few corrections and additions in map detail were reported by local authorities, to whom the maps under revision had been previously sent. These few details were inserted in the field, and in some sheets a considerable time was spent in getting these details to agree with those in the portion of the sheets taken up by the supplementary survey. In this way 6 standard sheets have been completed and are ready for publication. Seven others are in hand. This is a necessitous form of revision, and it can only be described as better than nothing, some of the surveys concerned being 40 years old.

67. *District maps*.—The district map of Jubbulpore is being prepared on 4 sheets on the $\frac{1}{2}$ -inch scale for reduction to the $\frac{1}{4}$ -inch, and a similar map will be prepared of each district as it is completed.

68. The programme for next field season is as follows:—

- (1) Supplementary topographical survey of 3,000 square miles to complete Saugor and Damoh districts, and part of Narsinghpur.
- (2) The traversing of 22 villages in Chanda district and any others that may be asked for by the local authorities.
- (3) The revision survey of all such portions of Mandla district, Rájputána and Central India, as fall into the standard sheets of Damoh and Saugor to complete them up to graticule limits.
- (4) Combined triangulation and traverse charts by standard sheets will also be commenced.

69. The party was inspected in the field by the Deputy Surveyor General on the 18th October 1903, and again in recess on the 28th July 1904, also by both the Surveyor General and Deputy Surveyor General on the 4th August 1904.

LOWER BURMA.

NO. 3 PARTY.

70. The main body of the party left recess quarters at Bangalore on the

Personnel.

Mr. E. F. Litchfield, Deputy Superintendent, 1st grade, in charge from 24th October 1903.

Mr. P. J. Doran, Extra Assistant Superintendent, 1st grade, in charge up to 23rd October 1903.

Mr. W. M. Gorman, Extra Assistant Superintendent, 6th grade.

Mr. J. Donaghey, " 6th "

Mr. E. Claudius, Sub-Assistant Superintendent, 2nd grade, "

Munshi Asmatulla Khan, " 2nd "

Mr. H. D. W. Stotesbury, " 3rd "

21 Sub-surveyors, etc., and 6 draftsmen.

18th November 1903, the triangulators having been sent in advance to Thayetmyo and Toungoo between the 15th and 28th October. Field work closed on the 19th May, and the recess office re-opened at Bangalore on the 30th May 1904. The outturn

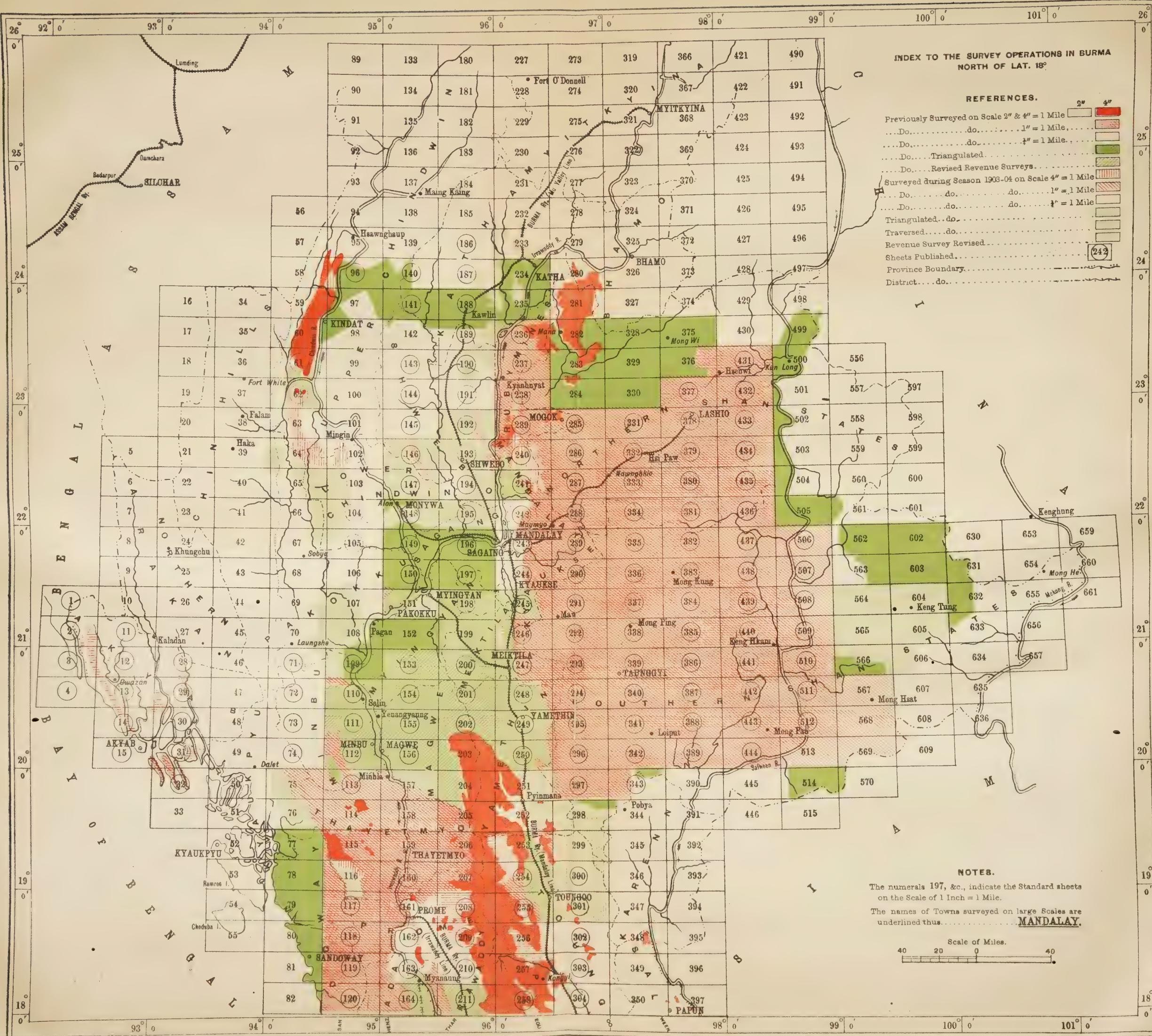
was as follows:—

	Square miles.
Triangulation	• 4,836
Detail survey on the 1-inch scale	• 2,148
Supplementary topographical survey on the 1-inch scale	• 455

71. The triangulation was carried out by Messrs. Gorman and Claudius, Munshi Asmatulla Khan and Sub-surveyors Abdul Hak and Ram Sarup. The area triangulated was very hilly and in the Yamethin and Toungoo districts densely forest clad, with a sparse population. In the Shan States the hills were bare and much cultivated by the Karens who congregate in large villages and from whom ready assistance was received. The supplementary survey was confined to two small hilly tracts in Magwe and Minbu districts, which had been cadastrally surveyed. The detail survey was checked by Mr. Donaghey and Munshi Asmatulla Khan. The boundary between Thayetmyo and the districts Kyaukpyu and Sandoway falls into the area surveyed, but as it has not yet been accurately defined, it could not be inserted on the field sections.

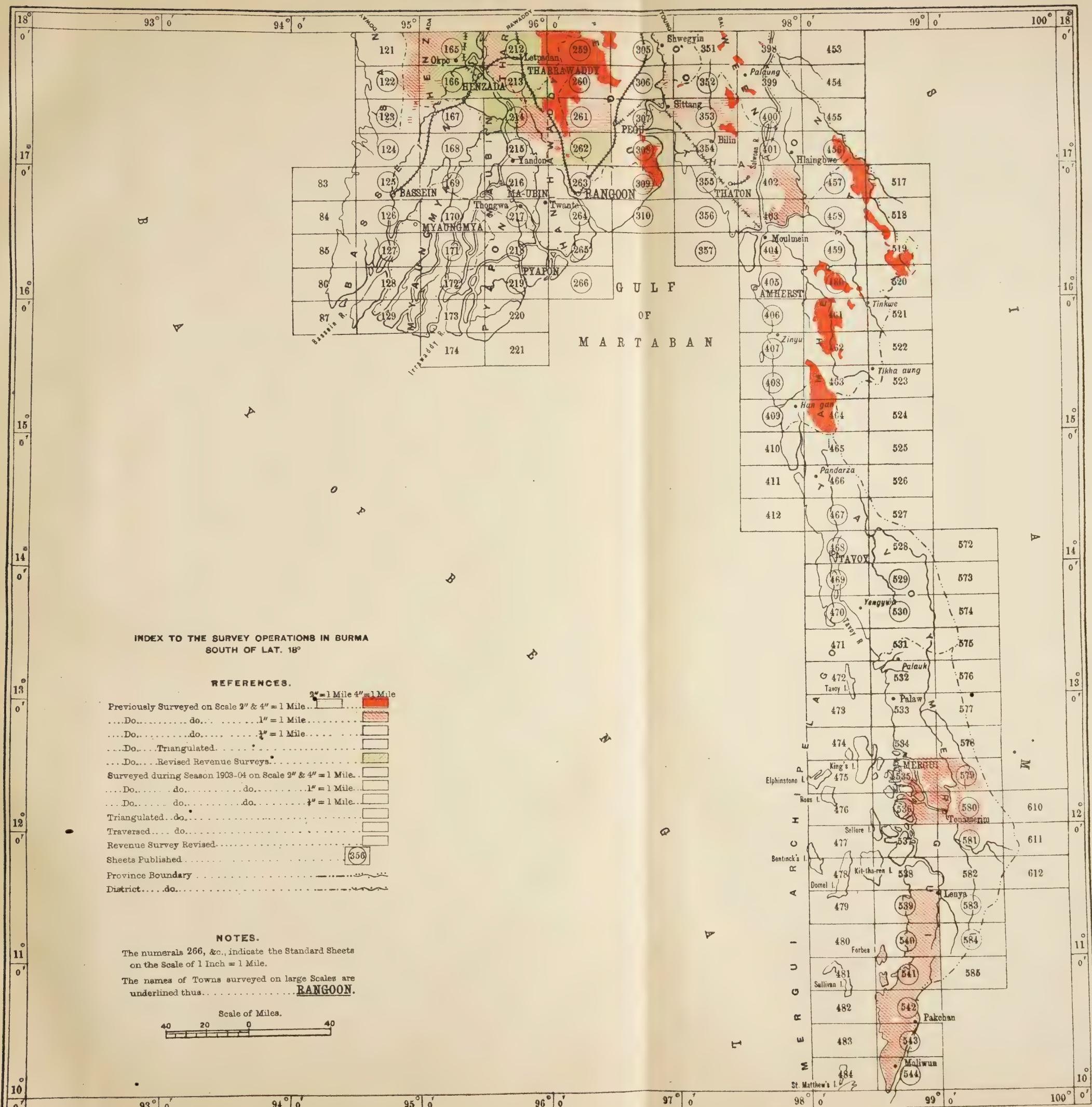
THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

BURMA SURVEY.



18°
0'
17°
0'
16°
0'
15°
0'
14°
0'
13°
0'
12°
0'
11°
0'
10°
0'

THE UNIVERSITY
OF THE
UNIVERSITY OF ILLINOIS



72. The cost-rates per square mile are :—

	<i>R</i>
Triangulation	10·8
Detail survey on the 1-inch scale	20·3
Supplementary survey on the 1-inch scale	16·0

The cost-rate of the supplementary survey is comparatively high on account of the hilly nature of the ground and the small area. Some intersected points were fixed by triangulation for the supplementary survey consisting of traverse stations of the cadastral survey and a few other points. The cost of this is not included in the above rates.

73. The season was a healthy one which may be attributed to the circumstances that the party took the field later than usual, and that the country worked in, overlaps the southern border of the dry zone.

74. The fair mapping which was in arrears has made good progress. Sheets 115, 117, 118, 119, 120, 163, 164, 259, 260, 261 and 262 have been published. Sheets 159, 165, 166, 254 and 255 are at press. Sheet 116 which was held back pending the completion of the 4-inch survey of the Mindon Yoma forest reserve will be sent to press shortly. Sheets 211 to 214 on examination were found to require correction in respect to several boundary questions which have now been settled. The sheets are ready and will soon be sent for publication. Four sheets remain, *viz.*, 204 to 207; the drawing of these sheets was stopped for adjustment with the work of the forest surveys in the adjoining sheets 251, 252 and 253. They will be completed during the field season. Sheet 253 compiled in Calcutta, is at press. The fair mapping of the current season's work in sheets 75, 76, 113, 114, 157, and 158 is well advanced and will probably be submitted for publication soon after the party again takes the field. Sheets 203 and 258 are being compiled in the headquarters office from various surveys. The spelling of names, as usual, was examined by the Translator to the Government of Burma and traces of the fair maps were submitted to the local officials for examination. Eight triangulation charts are in hand and two will shortly be sent to press.

75. The programme for the ensuing season consists of the triangulation of sheets 302, 303, 304, 305, 306, and 307, and the detail survey of sheets 251, 252, 298, 299 and 300 including supplementary survey of such portions as have been surveyed cadastrally.

76. The party was inspected in the field by Colonel Hobday, Deputy Surveyor General, in March, and again at Bangalore in September 1904.

UPPER BURMA.

NO. 10 PARTY.

Personnel.

Captain F. W. Pirrie, I. A. Deputy Superintendent, 2nd grade, in charge from 1st to 26th October 1903.

Lieutenant A. A. McHarg, R.E., Assistant Superintendent, 1st grade, in charge from 27th October 1903 to 16th June 1904.

Major J. M. Burn, R.E., Deputy Superintendent, 1st grade, in charge from 17th June to 24th July 1904.

Captain C. P. Gunter, R.E., Assistant Superintendent, 1st grade, in charge from 25th July 1904.

Mr. R. Waller-Senior, Extra Assistant Superintendent, 4th grade.

" P. J. Barrington, " " 5th "

" F. P. Walsh, " " 5th "

" W. G. Jarbo, Sub " " 1st "

" C. West, " " 2nd "

" E. M. Kenny, " " 3rd "

15 Sub-surveyors.

77. The party left recess quarters for the field towards the end of October 1903, and returned thereto between the 25th May and 9th June 1904. The operations were in continuation of those carried out in past years and consisted of topographical survey on the scale of 1-inch=1 mile

including supplementary survey on the same scale of such portions as had been previously cadastrally surveyed. Owing to the flat nature of the country the triangulation of the area surveyed in detail this year had to be supplemented by traversing, to provide a sufficient number of points for the plane-tables and special care taken to ensure accurate contouring. The traversing was carried out entirely by Provincial officers.

78. The outturn and cost-rates per square mile for the field season are as follows :—

Description of work.	Outturn.	Cost-rates.		
		R.	a.	p.
Triangulation	1,725 square miles.	10	8	2
Supplementary survey, 1-inch scale.	2,704 " "	26	0	9
New detail survey, 1-inch scale.	301 " "	27	4	10
Traversing	335 linear miles.	10	10	11

The secondary series of triangulation connecting the Manipur minor meridional series with the Mandalay series has been completed, and portions of sheets 69, 70, 106, 107, 108, 109 and 148 were triangulated. The detail survey comprises 1-inch standard sheets Nos. 146, 147, 192, 193, half of 194, 195 and a small area in 203. The nature of most of the ground surveyed rendered plan-tableting a matter of considerable difficulty. In Shwebo the country was flat and in parts heavily wooded and in Lower Chindwin the ground, though more undulating, was also covered with heavy jungle. In Sagaing again flat ground predominated. Consequently, the area surveyed in detail was not as large as expected, and the cost-rate of the detail survey shews a large increase on that of last year. The health of the party during the field season was good : Mr. Walsh fell ill and was obliged to proceed on medical leave.

79. The computations of the season's triangulation were completed as far as possible. The fair mapping of standard sheets 151, 198, 199, 203, and 250 left in arrears last year, was completed and will be sent for publication before field work is resumed, as also that of the whole of the current season's work in standard sheets 146, 147, 192, 193 and 195. The half of sheet 194 surveyed this year, has also been fair mapped. All the triangulation charts of the party have been brought up to date and three charts are complete and under despatch to Calcutta for publication.

80. The programme for the next field season is the triangulation of standard sheets 71, 72, 73, 74, 105, 106 and part of 107, the topographical survey on the scale of 1-inch=1 mile, partly new and partly supplementary, of standard sheets 148, 149, 150, half of 194, 196, 197 and the revision of the cadastral work in sheets 242, 243 and 244. The current five years' programme has been altered to enable this party to work more in unison with Nos. 7 and 20 Parties, and it is now as follows :—

Topographical survey on the 1-inch scale :—

1904—05 as above.	1906—07 sheets 143, 144, 145, 189, 190, 191.
1905—06 sheets 152, 109, 71, 72, 73, 74.	1907—08 " 187, 188, 234, 235, 280, 281

81. The party was inspected by the Deputy Surveyor General in September at Bangalore.

UPPER BURMA.

NO. 11 PARTY.

Personnel.

Mr. P. J. Doran, Extra Deputy Superintendent, 2nd grade, in charge from 26th October 1903 to 31st May 1904.

Captain C. P. Gunter, R.E., Assistant Superintendent, 1st grade, in charge from 1st June to 24th July 1904.

Major J. M. Burn, R.E., Deputy Superintendent, 1st grade, in charge from 25th July 1904.

Mr. W. M. Kelly, Extra Assistant Superintendent, 2nd grade.

Mr. J. H. Nichol, Extra Assistant Superintendent, 6th grade to 11th September 1904.

Babu Pramadarajan Roy, Sub-Assistant Superintendent, 1st grade.

Mr. H. C. W. Stotesbury, Sub-Assistant Superintendent, 2nd grade.

Mr. V. W. Morton, Sub-Assistant Superintendent, 2nd grade.

Mr. A. B. Hunter, Sub-Assistant Superintendent, 3rd grade.

Mr. P. D. Simpson, Sub-Assistant Superintendent, 3rd grade.

Munshi Abdul Rahim, K.S., Sub-Assistant Superintendent, 3rd grade.

19 Sub-surveyors.

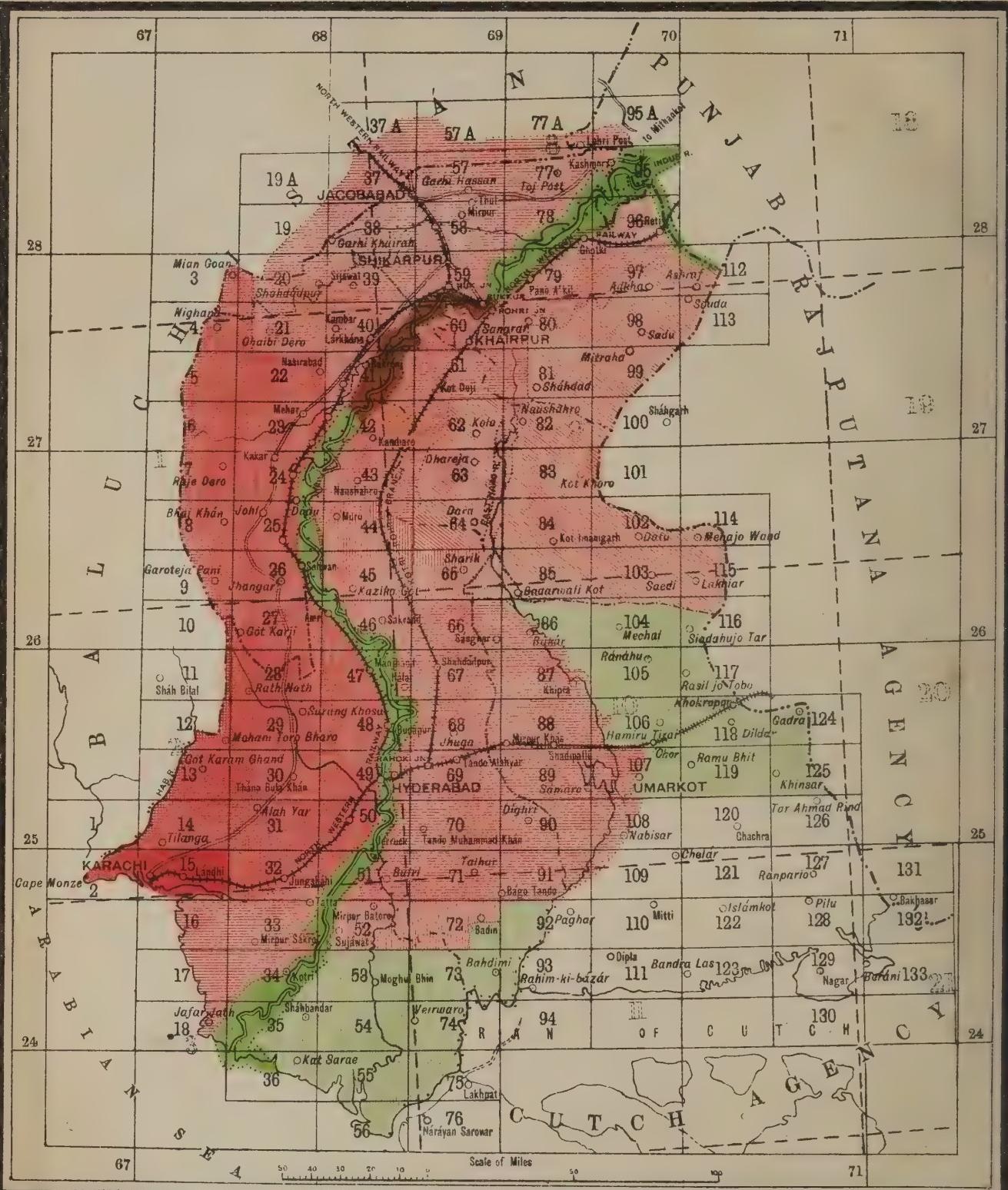
82. This party was placed under the Deputy Surveyor General from the 1st June 1904. The work during the season under report necessitated its division into two camps. The northern camp consisting of 7 sub-surveyors under Mr. Doran surveyed, on the 1-inch scale, the portions of sheets 506, 507, 508 lying to the east of the Salween river, while Mr. Kelly with 12 sub-surveyors conducted similar operations in sheets 513, 568, 569 and 609 up to the Burma Siam boundary and the whole of 567. Munshi Abdul Rahim, K.S., accompanied Lieutenant D. Forster, R.E., of the Burma Sappers and Miners in erecting pillars on the Burma China boundary.

*THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS*

SIND SURVEY.

1903-1904.

No. 12 and 16 PARTIES



No. D. 2 S. I. 9-9-1904 - 650

Heliocinographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Doon, September 1904.

REFERENCES.

Surveyed in previous Seasons Scale $1'' = 1$ Mile by No. 12 Party.

Do. do. $1'' = 1$ Mile do. [red square]

Do. do. $1'' = 1$ Mile do. [brown square]

Do. do. $1'' = 1$ Mile do. [red square]

Do. 1903-1904 $2'' = 1$ Mile do. [red square]

Triangulated and Traversed in advance do. [brown square]

Surveyed in previous Seasons Scale $1'' = 1$ Mile by No. 16 Party.

Indus Riverain Survey [green square]

Reg. No. 283-S 04.

NOTES.

The numerals 63, etc., indicate the Standard sheets on the Scale 1 inch = 1 Mile.

The figures and lines in strokes represent the numbers and limits of the Engraved sheets of the Indian Atlas.

83. The party left Bangalore at the end of October and reached its destination about the middle of December, though the last man did not commence work till the first week of January. Field work closed about the middle of April and the party returned to recess quarters early in June. The country surveyed in detail embraced portions of the Shan States of Nonglün, Kēng Tung and Möng Pan and though mountainous and generally covered with heavy jungle, specially in sheets 567, 568, 569 and 609 was, with the exception of one or two localities, fairly well inhabited and furnished with foot-paths and mule tracks. The outturn for the season and cost-rates are:—

	Square miles.	Cost per square mile.
	<i>R</i>	
Triangulation	2,714	10·0
Detail survey on the 1-inch scale	3,153	25·3

84. The triangulation was carried out by Babu P. Roy and Messrs. H. C. W. Stotesbury and Morton in sheets 604, 605, 564, 565 and portions of 566 and 606. These officers also assisted in checking the detail survey. The outturn of triangulation is almost the same as that of last year, but the detail survey is about 700 square miles in excess. Work was much hampered by heavy mist in December and January, and dense haze in March and April, and a good deal of sickness was experienced. Thanks to the good offices of the Superintendent of the Shan States, Sir George Scott, much assistance was received from the Government of Siam, who deputed an official to facilitate arrangements for the work along the boundary.

85. During recess the fair drawing was completed of sheets 506, 507, 508, 513, 567, 568, 569 and 609 for publication in two colours and also of 10 triangulation charts which were submitted for publication. Four charts are still in hand. The computations of the triangulation were also completed.

86. This party will be employed during next season on the North-West Frontier under the administration of the Surveyor General.

87. The party was inspected by the Deputy Surveyor General in September 1904, at Bangalore.

SIND.

NO. 12 PARTY.

88. The following programme was completed:—

- (a) Network of secondary triangulation in two blocks, one running through the Karachi district in portions of sheets 35, 53, 54, 55, 73, 74 and 75, and the other through the Thar and Párkar district in portions of sheets 85, 87, 104, 105, 106, 107, 116, 117, 118, 119, 124 and 125.
- (b) Village boundary traversing in portions of sheets 44, 45, 46, 65, 66, 67, 68, 87, 88, 89, 90 and 91.
- (c) The detail survey on the 2-inch scale of portions of standard sheets 44, 45, 46, 52, 65, 72, 85 and 86.

(d) Lieutenant Rich during his absence from the party, triangulated an area of about 1,722 square miles in Berar (Central Provinces) in advance of detail survey which will be taken up by a new topographical party next field season.

89. The recess office at Karachi was closed on the 26th October 1903, and the party assembled at Nawabshah on the 1st November.

90. The traversing consisted as in former years, in following the village boundaries with offsets. There were 6 main circuits measured, 25 sub-circuits and 29 connecting lines. The angular work was checked by observations for azimuth at 99 stations on main and sub-circuits, the average angular error per station being '53". The linear measurements amounted to 2,456 miles and were checked by 17 connections with the stations of the minor triangulation executed by this party, and with some stations of the Sehwán secondary series. The average correction per 1,000 links was 0'39 links. No permanent marks were laid down at traverse stations, but the marks erected by the revenue authorities to demarcate village boundaries have been utilized and the angles of the village boundaries fixed by offsets. The cost of traversing amounts to Rs 9-15-9 per square mile.

91. The area surveyed in detail on 2-inch scale amounts to 2,715 square miles. The survey was carried out entirely by interpolation. It was tested from 1,212 *in situ* fixings, and was carried out under the direct supervision of the officer in charge. The cost is Rs 10-3-3 per square mile.

92. Field work closed by the end of March 1904, and the party returned to Karachi for recess. The health of the party during the field season was only fair, there being many cases of pneumonia. From this complaint four *khalásis* died in the field, and the best surveyor in the party died of consumption soon after the close of the field season.

93. During recess the fair mapping of the entire area surveyed was completed. The mapping comprised 30 quarter sections. They were drawn on the 2-inch scale for reduction, and have all been despatched to the Trigonometrical office, Dehra Dún, for publication. Two maps of $\frac{1}{2}$ -inch work have been completed and sent for reproduction and publication, and the one remaining will be sent on completion of the drawing. The Sukkur district map is being drawn on the $\frac{1}{2}$ -inch scale for publication on the $\frac{1}{4}$ -inch scale.

The triangulation and traverse charts of sheets 34, 35, 44, 45, 46, 53, 54, 55, 65, 72, 73, 74, 75, and 104 have been drawn and despatched to Dehra with list of co-ordinates. Those of sheets 86, 105, 106 and 107 are in hand.

94. Next season triangulation in advance will be taken up in sheets 91, 92, 93, 94, 108, 109, 110, 111, 120, 121, 122, 123, 126, 127, 128, 129, 130, 131, 132, and 133. Detail survey on 2-inch scale will be carried on in sheets 34, 35, 53, 54, 72, 73, 74, 92, 93 and 94, and that on 1-inch scale in sheets 36, 55, 56, 75 and 76.

95. The party was inspected by the Superintendent, Trigonometrical Surveys, in April 1904.

UNITED PROVINCES OF AGRA AND OUDH.

NO. 14 PARTY.

96. The survey operations during the season included :—

Personnel.

Captain C. W. H. Symonds, I. A., Deputy Superintendent, 1st grade, in charge up to 21st October 1903.

Captain H. L. Crosthwait, R.E., " " 2nd " in charge from 22nd October 1903.

Mr. W. H. Penrose, Extra Assistant Superintendent, 3rd grade, from 6th November 1903 to 16th January 1904.

Mr. C. George, Extra Assistant Superintendent, 4th grade, from 11th January 1904.

Mr. J. H. S. Wilson, " " 6th " from 31st October 1903.

Mr. E. J. Biggie, " " 6th "

Mr. J. R. Newland, Sub-Assistant Superintendent, 2nd grade, up to 5th November 1903.

Mr. H. B. Simons, " " 2nd " 73 Surveyors, etc., and 2 writers.

(a) *Traversing of remaining portion of Fatehpur, and the whole of Cawnpore districts.*

(b) *Topographical survey on a scale of 2 inches = 1 mile in Allahabad and Fatehpur districts.*

(c) *Supplementary topographical survey in Partabgarh district to complete sheets to graticule limits.*

(d) *Revision survey for the same purpose in standard sheets bordering on the east and south of Allahabad district.*

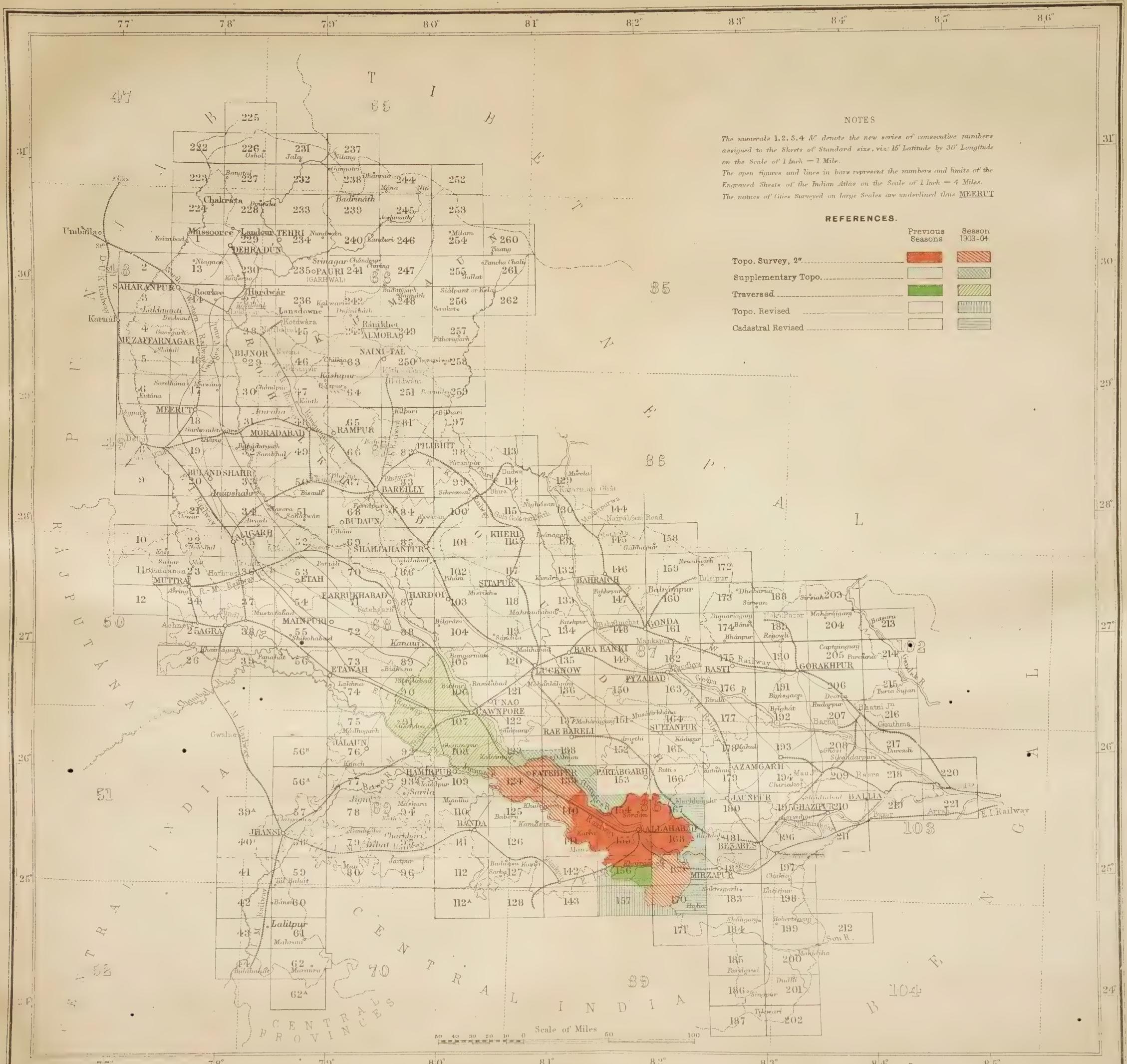
97. The field office opened at Cawnpore on 15th October 1903; work closed on 25th April 1904; the recess office opened at Mussooree on 5th May

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

UNITED PROVINCES.
INDEX TO THE SURVEY OPERATIONS

No. 14 PARTY.

1903-04.



NOTES

The numerals 1, 2, 3, 4 &c denote the new series of consecutive numbers assigned to the Sheets of Standard size, viz: 15' Latitude by 30' Longitude on the Scale of 1 Inch = 1 Mile.

The open figures and lines in bars represent the numbers and limits of the Engraved Sheets of the Indian Atlas on the Scale of 1 Inch = 4 Miles. The names of Towns Surveyed on large Scales are underlined thus MEERUT

REFERENCES.

	Previous Seasons	Season 1903-04.
Topo. Survey, 2"		
Supplementary Topo.		
Traversed		
Topo. Revised		
Cadastral Revised		

1904. Mr. C. George was in charge of the traverse camp and field drawing office; Messrs. Wilson, Biggie, and Simons were employed in charge of field camps, and of drawing sections during the recess.

98. The following tabular statement is a summary of work completed during the field season, and the cost-rates of the same:—

DISTRICT.	DEMARCATION.		TRaversing.		TRIANGULATION.		TOPOGRAPHY $2''=1$ MILE.	
	Square miles.	Cost per square mile.	Square miles.	Cost per square mile.	Square miles.	Cost per square mile.	Square miles.	Cost per square mile.
Allahabad.	...	R a. p.	...	R a. p.	650	R a. p. 2 10 1		R a. p.
Fatehpur.							*2221	9 14 1
Cawnpore.	2911	1 14 8	2911	15 7 9	...	...

* Includes 285 square miles of supplementary survey in districts Partabgarh and Rai Bareli.

99. The origins used for the survey were as follows:—

Allahabad	.	.	longitude $81^{\circ} 45'$	latitude $25^{\circ} 15'$
Fatehpur	:	:	" $80^{\circ} 45'$	" $25^{\circ} 45'$
Cawnpore	:	:	" $80^{\circ} 15'$	" $26^{\circ} 15'$

100. The area topographically surveyed on the scale of 2 inches=1 mile, is contained in the following standard sheets of the United Provinces:—Nos. 124, 125, 139, 140, 141, 154, 155, 156, 157, 167, 168, 169 and 170. The mapping of almost all this work has been completed.

101. The country traversed and topographically surveyed was similar to that of last season and no special difficulty was encountered.

102. The programme for the coming field season is as follows:—

- (a) *Topographical survey* on a scale of 2 inches=1 mile in Allahabad, Fatehpur and Cawnpore districts of 2,173 square miles.
- (b) *Supplementary topographical survey* to complete sheets to graticule limits amounting to 327 square miles.

103. On the completion of the topographical survey of these districts this party will in future be placed at the disposal of the military authorities for work which is required for military purposes.

104. The party was inspected by the Deputy Surveyor General in October 1903, and by the Surveyor General in August 1904.

NORTH-WEST FRONTIER.

NO. 15 PARTY.

Personnel.

Mr. E. A. Wainright, Extra Deputy Superintendent, 2nd grade, in charge up to 17th December 1903.

Captain F. W. Pirrie, I.A., Deputy Superintendent, 2nd grade, in charge from 18th December 1903.

Lieutenant R. H. Phillimore, R.E., Assistant Superintendent, 2nd grade, from 15th August 1904.

Mr. J. McHatton, Extra Deputy Superintendent, 2nd grade.

Mr. G. A. Knight, Extra Assistant Superintendent, 2nd grade.

Munshi Imam Sharif, K.B., " 5th grade.

Mr. H. C. H. Cooper, " 6th grade.

Subadar Kanak Singh, Sub-Assistant Superintendent, 2nd grade.

Mr. E. B. West, " 2nd grade.

Mr. E. C. O'Sullivan, " 3rd "

40 Surveyors, sub-surveyors, etc.

105. The programme consisted of triangulation and detail survey in Baluchistan, the survey of the cantonments of Ferozepore, Amritsar, Jhelum, and Jullunder and their bazars, and traversing in Baluchistan for settlement surveys.

The total outturn and cost-rates are given below :—

	Areas.	Cost-rates.
		<i>R</i>
Triangulation	1,460 square miles	7 13 9
Detail survey	1,287 "	53 6 0
Cantonment survey	59 "	250 4 4
Traversing for cantonment surveys	59 linear miles	59 8 0 per linr. mile
Baluchistan settlement traversing	1,624 "	7 13 8 "

106. The field season lasted from October 1903 to June 1904, and the party again left for the field early in September 1904.

The cantonment detachment worked under the immediate supervision of Mr. J. McHatton and the settlement traversing in Baluchistan was carried out by Khan Bahadur Imam Sharif.

107. There was a certain amount of fever in September, October and November 1903, and three cases of pneumonia, but although the field season was very long the health of the party was good. Sub-surveyor Abdul Jalil, who left the party on 16th October 1903, was killed when on duty with the Aden detachment. By his death the party loses a conscientious frontier surveyor who has done much useful work.

108. In February 1904, a statement was made out shewing the time it would take to complete the triangulation volumes and charts of Baluchistan, and as it was necessary to have an officer with experience and knowledge to supervise the work done by the party in Baluchistan, Mr. E. A. Wainright, who had retired from the service on 18th December 1903, was re-employed and appointed to superintend the work from 18th July 1904.

109. The programme for the field season 1904-05, consists of triangulation and detail survey in Baluchistan, the North-West Frontier Province and tribal area, and the survey of cantonments and their bazars, of Siálkot, Ráwalpindi, Dera Ismail Khan, Nowshera, Murree and Cherat. No. 11 Party will be transferred from the Shan States in Burma as a temporary measure to assist the party in special surveys on the North-West Frontier.

110. An attempt will be made to prepare the field sheets of cantonments and bazars for reproduction by photozincography so as to avoid the labour and time taken in fair drawing them.

111. Mr. J. McHatton, who would have retired on pension on attaining the age of 55 years on 17th July 1904, was granted an extension of service for one year for employment on cantonment surveys.

112. The party was inspected by the Surveyor General, and Deputy Surveyor General during the recess.

PUNJAB.

No. 18 PARTY.

113. The party was transferred from the administrative control of the Deputy Surveyor General, to that of the Surveyor General, on the 1st June 1904.

Captain E. A. Tandy, R.E., Officiating Deputy Superintendent, 2nd grade, in charge.

Mr. W. Robert, Extra Deputy Superintendent, 2nd grade.
" G. C. Swiney, Extra Assistant Superintendent, 2nd grade, retired 27th June 1904.

Mr. G. J. S. Rae, " " " 5th ,
from 25th June 1904.

Mr. J. O. Greiff, " " " 6th "
" C. E. C. French, " " " 6th "
" J. R. Newland, Sub-Assistant Superintendent, 1st "

Babu Maya Das Puri, " " " 2nd "
Mr. C. E. Tapsell, retired Provincial Officer, from 8th September 1904.

80 Surveyors, draftsmen, etc.

have accordingly been a very serious distraction to the conduct of the ordinary topographical work; and secondly, that the drawing section has been steadily strengthened, by the enlistment and training of fresh draftsmen, and by the appointment of a retired provincial officer to supervise it; so that a satisfactory commencement has been made in the disposal of the heavy arrears of fair map-

114. The work was again of an extremely diverse nature, and will be described under seven separate heads.

The chief points of note during the year are, first, that the riverain surveys were even more extensive and scattered than previously, and

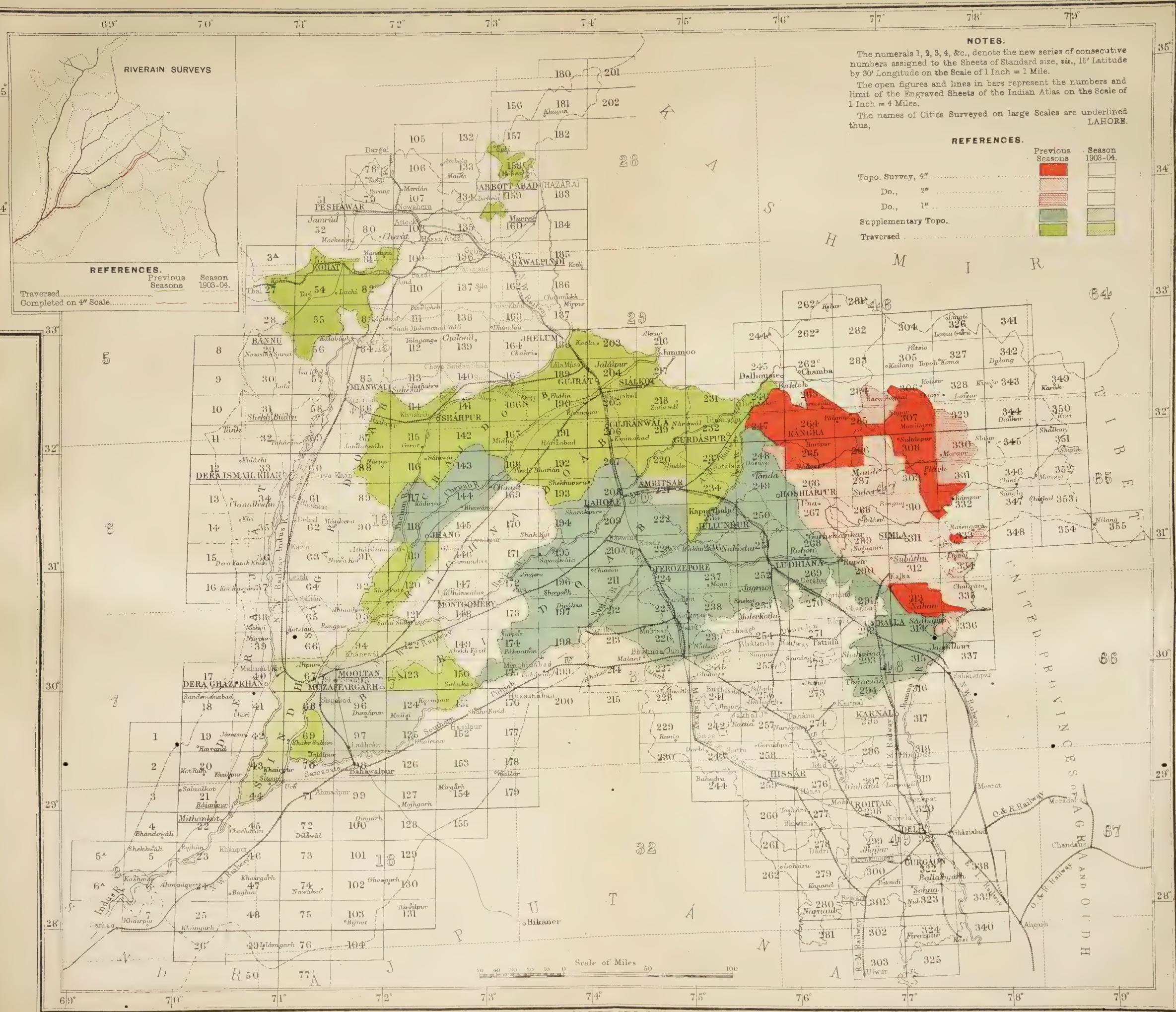
THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

PUNJAB & N. W. FRONTIER PROVINCE.

INDEX TO SURVEY OPERATIONS.

1903-04.

NO. 18 PARTY.



ping due to the extensive large scale surveys which the party has taken up of late years.

115. The field season commenced early in November and closed about the middle of May, though a few detachments were sent in October to work on the Sutlej south of Multán district. It was a most unhealthy autumn, and nearly all the men who were sent down early suffered so severely from fever, for a month or two, that little or nothing was gained by their having commenced before the others. One amongst these men died in November; late in the season two *khalásis* died of plague, in Jullundur and Amritsar, and one surveyor showed severe symptoms of it but recovered. Otherwise, except for a good deal of suffering from boils as the weather became hot, the health of the party was good.

116. *Supplementary topographical survey on the 2-inch scale.*—This work consisted, as in previous years, of testing by plane-table, a compilation of settlement *masavis* fitted together by means of points previously determined by traverse work. The area completed was 2,669 square miles in Multán district, and 421 square miles in Amritsar; besides which the old 6-inch map of Amritsar and environs, dated 1869, was brought up to date, and an area of 82 square miles was surveyed in Baháwalpur State to complete a standard sheet to graticule limits. The *masavis* of Multán district are very recent and for the most part sufficiently accurate for the 2-inch scale; the work was accordingly pushed on with a degree of rapidity which was only attainable by placing considerable reliance on the results of compilation. It has been decided that the accuracy so obtained is too conjectural, and that in future sufficient time is to be spent on every portion of the work to afford independent evidence as to the real accuracy of the settlement surveys. There has also been a tendency in this work to survey too rapidly and roughly, features lying in waste and desert tracts, and, though the latest maps show some improvement in this respect, henceforward the survey of all portions of the ground will be equally thorough and complete.

117. *Revision survey.*—To avoid the publication of new standard sheets in a fragmentary form, revision surveys were undertaken in those portions of three sheets which fall in Ferozepore district. The existing maps were about 17 years old; information was first obtained from all local officials as to any corrections which might be required, and surveyors were then sent to revise on the ground the details thus indicated. This procedure proved economical, and is satisfactory as far as it goes; though the assistance of local officials in such matters is liable to be somewhat perfunctory, and there is, therefore, no guarantee that the whole area has been thoroughly brought up to date in every possible respect.

118. *Traversing.*—This was continued in Multán and Muzaffargarh districts, with a view to affording fixed points on which the 2-inch compilation and supplementary surveys are based. The conditions were generally favourable for the utilization of the old traverse records of 1854, and the procedure for doing this was much developed, with the result that an outturn of 3,441 square miles was effected at a greatly reduced cost.

119. *Riverain surveys.*—The general object of this work has been described in previous reports. During the past year a good deal has been done, in conjunction with the Punjab Government, to develop various details of procedure so as to increase the value of the results, and make them more suitable for the future use of the Settlement Department. Various riverain traverses were run over extensive reaches of the rivers Sutlej, Beas, Jhelum, Panjnád, and Indus; in districts Multán, Muzaffargarh, Dera Gházi Khan, Dera Ismail Khan, Miánwáli, Jullundur, Ludhiána, Amritsar, Gurdáspur, Hoshiárpur, Gujrát, and Jhelum; and in Baháwalpur, Kapurthala and Kashmir States; comprising a total area of 1,284 square miles of new traverse and a great deal of very troublesome supplementary traversing in old areas. Riverain plane-tableing, on the Indus, Panjnád, and Sutlej rivers, embraced an area 1,705 square miles; but it is proposed to discontinue this work in future, as it is impossible to carry it on in such scattered localities without very serious detriment to the ordinary work of the party.

120. *Reduction and compilation of masavis.*—Over 9,000 *masavis* of Multán and Muzaffargarh were reduced to the 2-inch scale, and their compilation as a basis for the new standard sheets is well advanced. Nearly

10,000 riverain *masavis* were reduced to the 4-inch scale, and the compilation of 207 riverain sheets was carried out; the whole of the riverain compilation will have to be amplified on account of the latest arrangements, under which all sensible discrepancies are to be clearly shown on the riverain maps.

121. *Simla surveys.*—The protracted work of mapping all the estate boundaries in Simla on a scale of 50 feet = 1 inch was at last completed, by the survey of the new railway line and its boundaries and the revision of the 17 sheets in which it falls. Progress was constantly delayed on account of the difficulty of getting the railway officials to arrange for the complete demarcation of their boundaries. A good deal of scattered work was carried out, on the 6-inch scale, in Mashobra, Naldera and Mahasu, in connection with the suggested extensions of Simla; further extensive surveys of the same nature were called for afterwards, but the work had to be refused as it would have caused serious detriment to the normal work of the party.

122. *Mapping.*—The whole of the 112 fair sheets of the Simla boundaries survey, with index sheets, etc., were completed and sent to press by the end of the recess season.

The arrears of mapping in the Punjab plains were nearly cleared off, while fair progress was made with the current fair maps.

These results were only obtained by keeping in abeyance the fair drawing of riverain surveys which are not urgently required, and by holding over all the arrears of Himalayan work during the first half of the year; a commencement was made in the disposal of these latter by detailing a small section to take them up during the recess season; this section is to occupy itself solely with Himalayan arrears throughout the year, and will be gradually strengthened as more draftsmen become fit for hill drawing. A good deal of difficulty has been experienced in enlisting and training suitable draftsmen, and it will be some time before the drawing sections can produce rapid and satisfactory work and bring themselves properly abreast of requirements.

123. *Programme for next field season.*—This allows for the continuation of 2-inch surveys in the neighbourhood of Multán and Muzaffargarh, and the extension of the district traverse work to the north and north-east; also for riverain traverses in various localities of the Punjab, and a special 6-inch contoured survey for military purposes in the neighbourhood of Khushálgarh on the Indus.

124. The party was inspected by the Deputy Surveyor General in June, and by the Surveyor General on various occasions during the year under report.

FOREST SURVEYS.

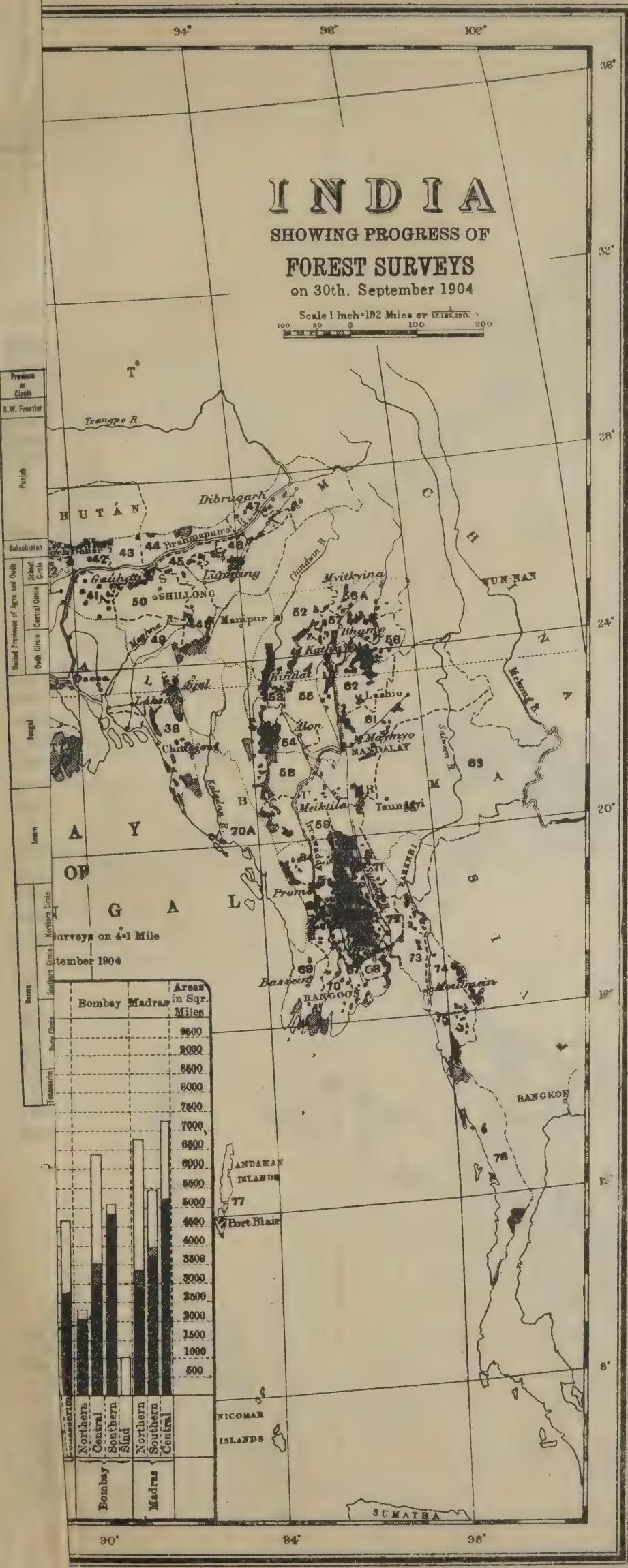
No. 9 PARTY (FORESTS).

125. This party was formed, after the unification of the Forest Survey Personnel.

The Superintendent of Forest Surveys in charge.
Mr. J. Marten, Extra Assistant Superintendent, 3rd grade.
" A. Ewing, " " " 4th "
" C. Litchfield, " " " 6th "
" C. J. Veale, Sub " " " 1st "
" P. A. T. Kenny, " " " 2nd "
2 Surveyors and 89 sub-surveyors.

Branch, out of the various Forest Survey detachments which had hitherto not been attached to any party. The Superintendent of Forest Surveys held executive charge in addition to his other duties.

126. The *locale* of operations, as formerly, lay in those districts in the Bengal Presidency where there was not sufficient forest survey work for a complete party; one detachment under Mr. J. Marten continued the survey of the forests in the Gáro hills, Kámrup, and Nowgong districts in Assam, two detachments under Mr. A. Ewing and Mr. P. A. T. Kenny worked in the Mandalay, Katha and Shwebo districts in Upper Burma, another detachment under Mr. Veale completed forest surveys in the Darjeeling district, Bengal, while smaller sections under native surveyors worked in the Punjab, Bengal, and the United Provinces.



Photocopies taken at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun.

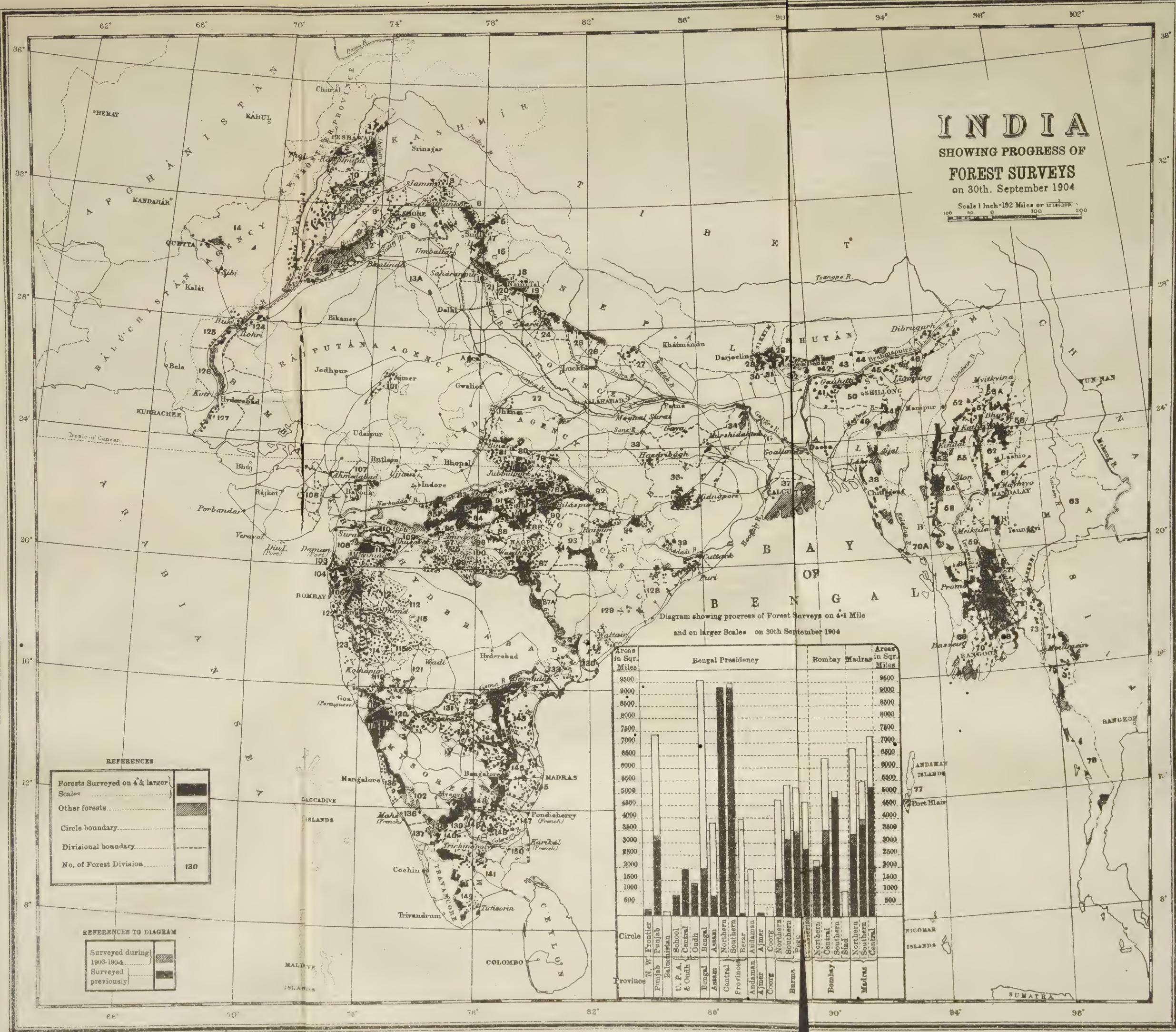
Reg. No. 49-S.05.

INDIA

SHOWING PROGRESS OF
FOREST SURVEYS
on 30th. September 1904

Scale 1 Inch = 152 Miles or 1:161,000
100 50 0 100 200

Province or Circle	Reference No. on Map	Division	Province or Circle	Reference No. on Map	Division
K. W. Frontier	1	Balura	Kashmir	75	Muzrai
Punjab	2	Rupnagari	76	Andamad	
	3	Chakna	77	Mardia	
	4	Kangra	78	Jobulwara	
	5	Bankar	80	Ganoh	
	6	Kalis	81	Sang	
	7	Sind	82	Harrangpur	
	8	Lahore	83	Hwanghaen	
	9	Chesab	84	Betul.	
	10	Jhelum	85	Nimer	
	11	Shaper	86	Kager Wardha	
	12	Abrohongary	87	New Chorda	
	13	Modian	88	Bhandar	
	13A	Hissar	89	Sohn	
Baluchistan	14	Baluchistan	90	Salaqat	
United Provinces of Agra and Oudh	15	Dogra One	91	Chitwan	
	16	Sikar	92	Bilaspur	
	17	Jaunpur	93	Balur	
	18	Mathura	94	Sambaler	
	19	Kosana	95	Khokhar	
	20	Gardawal	96	Balasa	
	21	Gangas	97	Basim	
	22	Burdelikond	98	Wan	
	23	Pithor	99	Shapar	
	24	Kher	100	Wan	
	25	Bakrak			
	26	Ganda			
	27	Burkpur			
Bengal	28	Darjeeling			
	29	Tista			
	30	Karsong			
	31	Jingpo			
	32	Baxa			
	33	Palance			
	34	Sentul Parganas			
	35	Sitakunam			
	36	Sitakunam			
	37	Chittagong			
	38	Angul			
	39	Angul			
	40	Paro			
Assam	41	Garo Hills			
	42	Guadipora			
	43	Kiteng			
	44	Darong			
	45	Houeng			
	46	Shapar			
	47	Lakshimpur			
	48	Cochar			
	49	Sylhet			
	50	Khas and Jaintia Hills			
Burma	51	Upper Chindwin			
	52	Myethna			
	53	Lower Chindwin			
	54	Wa			
	55	Okha			
	56	Myitkyina			
	57	Aizha			
Madras	58	Minbu			
	59	Pyinma			
	60	Mandalay			
	61	Myitkyina			
	62	Ruby			
	63	Colo Shan States			
	64	Hawmeyo			
	65	Prone			
	66	Dhamraweddy			
	67	Rangoon			
	68	Port Blair			
	69	Bassein Myutengnya			
	70	Arakan			
	71	Tengwe			
	72	Amawyan			
	73	Wadu			
	74	Thamene			
Orissa	75	Tengwe			
	76	Wadu			
	77	Thamene			



127. The outturn and cost-rates for the year under report and the two previous years are given in the following table:—

DESCRIPTION OF SURVEY.	OUTTURN IN SQUARE MILES.			COST-RATES PER SQUARE MILE.		
	1901-1902.	1902-1903.	1903-1904.	1901-1902.	1902-1903.	1903-1904.
<i>Detail survey 4 inches = 1 mile.</i>						
Bengal	427	232	310	48·2	64·0	64·0
Assam . . . . .	...	134	160	...	97·8	85·2
Punjab and North-West Frontier.	112	300	209 (a)	23·1	35·3	25·0
United Provinces . . . . .	...	100	36	...	29·7	27·1
Burma	274	303	447	85·9	63·5	90·7
Central Provinces	1,424	226	25	29·4	25·7	57·6
TOTAL . . .	2,237	1,295	1,164·5			
Traversing	646 (b)	1,251 (b)	1,552 (b)	17·7 (c)	22·9 (c)	23·9 (c)
Triangulation	1,962	990	2,483	4·3	10·4	7·7

(a) Outline survey.

(b) Linear miles.

(c) Per linear mile.

The outturn of detail survey is less than for 1902-03, and only about half that of 1901-02: this is due to the easy surveys in the Central Provinces, where a large outturn at cheap rates formed the bulk of the work. The detachments are now chiefly employed in Burma, Assam, and Bengal, where, owing to expenses of transport and the natural difficulties of the country under survey, a much smaller outturn is to be expected. Except in Burma and the Central Provinces, the rates for detail survey are lower than for last season: the increase in the rates for the Central Provinces is due to the small area surveyed, and that for Burma, entirely to the more difficult nature of the country.

Formerly the detachments now forming No. 9 Party worked chiefly in districts where triangulation and traverse data were available; now the party has to undertake most of its own triangulation and traversing, which accounts for the large increase in these operations. The cost-rates of both are moderate and compare favourably, considering the nature of the country, with the rates of former years.

128. During the year good progress was made in drawing and publication of the maps, and it is hoped that by next year all arrears will be cleared off.

129. The programme for 1904-05 consists of 4-inch detail surveys in Burma, Bengal, Assam, and the North-West Frontier Province, and triangulation and traversing in the same Provinces excluding the North-West Frontier Province. Preliminary traversing and triangulation will also probably be undertaken in Berar, in preparation for a 4-inch survey of 730 square miles of forest reserves which is urgently required owing to the increasing value of the forests.

130. The party was inspected during the recess by the Surveyor General.

BOMBAY PRESIDENCY.

NO. 17 PARTY.

Personnel.

Mr. B. G. Gilbert-Cooper, Officiating Superintendent, 2nd grade, in charge.

Mr. S. F. Norman, Extra Assistant Superintendent, 3rd grade.

Babu Amar Singh, Extra Assistant Superintendent, 6th grade, from 26th October 1903.

Mr. C. J. Veale, Sub-Assistant Superintendent, 1st grade, up to 28th October 1903.

Mr. P. R. Anderson, Sub-Assistant Superintendent, 1st grade.

2 Surveyors, 34 sub-surveyors, etc., and 1 writer.

131. The various camps of this party left Poona for the field at the end of November, and returned to recess quarters early in June, giving a full working season of six months.

The party was divided into three camps under Mr. S. F. Norman, Babu Amar Singh, and Mr. P. R. Anderson, respectively, and continued the survey on

various scales of forest areas in the Northern and Central circles of the Bombay Presidency ; these operations comprised :—

- 1 *Northern circle*.—Detail survey on the 8-inch scale of the teak reserves of the Sháhápúr *taluka* of the Thána district.
- 2 *Central circle*.—Supplementary triangulation and detail survey on the 4-inch scale in the Sátára district. Detail survey on the 8-inch scale in the Peint *taluka* of the Násik district, together with the completion of a small area (10 square miles) of detail survey on the 8-inch scale in the Málegaon *taluka* of the same district. The 8-inch surveys were confined to the more valuable "teak" reserves. Supplementary triangulation, and detail survey on the 4-inch scale in the Khándesh district.

In addition to the above, the special survey on the scale of 16 inches=1 mile of Mátherán hill station was undertaken and completed.

132. There was a good deal of sickness, and the services of 3 sub-surveyors were lost to the party for almost the entire field season from this cause.

133. The following table shows in detail the outturn, with cost-rates, for the year under report, and the two previous years :—

DESCRIPTION OF SURVEY.	OUTTURN IN SQUARE MILES.			COST-RATES PER SQUARE MILE.		
	1901-1902.	1902-1903.	1903-1904.	1901-1902.	1902-1903.	1903-1904.
Triangulation	320	1,373	677	R 19·6	R 1·11	R 15·3
Topography, 4-inch scale . . .	607	487	576	63·8	61·0	67·5
Topography, 8-inch scale . . .	162	240	158	136·1	130·0	138·8

The cost-rate for triangulation is higher this year than last, but does not exceed the mean of the two previous years; the slight increase to the rates is due to the smaller area, and to the country being more thickly wooded. That for 4-inch detail survey is rather higher than for the two previous years, which is owing to the scattered nature of the forest areas in the Sátára district, and to some loss of time in picking up "Proposed forest" boundaries, especially in *mami* villages, where no Revenue Survey maps were available as a guide to the surveyors. The cost-rate of the 8-inch detail survey is also rather higher than last year's for similar work, but very slightly in excess of that of the previous year. This is, in a measure, due to the loss in outturn owing to 2 of the best surveyors having been employed on the special survey of Mátherán hill station for the greater part of the season, and the loss of the services of 3 sub-surveyors from sickness for almost the entire field season.

134. During the recess good progress has been made with the mapping of the current season's work, and nearly all arrears of mapping of the former season's field work have been worked off, 117 maps were sent to press during the year under report, and it is expected that 100 more maps will be forwarded for publication by the end of November.

135. During the year, at the request of the Government of Bombay, a special survey on the scale of 16 inches=1 mile of Mátherán hill station was (together with the fair mapping appertaining thereto), completed. The whole plateau, covering an area of 3·33 square miles was most carefully surveyed, with contours having a vertical interval of 12½ feet. The cost of the survey, which amounted to R 3,400-14-0, was borne by the Mátherán station fund.

136. The programme for 1904-05, is in continuation of that for the past season. The 8-inch detail surveys of Thána and Násik will be continued, and triangulation and 4-inch surveys will be continued in Sátára and Khándesh.

137. The party was inspected in September by Major C. W. H. Symonds, I. A., Officiating Superintendent, Forest Surveys, and early in October, by the Deputy Surveyor General on behalf of the Surveyor General.

MADRAS PRESIDENCY.

NO. 19 PARTY.

Personnel.

Captain C. L. Robertson, C.M.G., R.E., Deputy Superintendent, 1st grade, in charge.

Mr. G. T. Hall, Extra Assistant Superintendent, 1st grade, in temporary charge from 16th April to 15th July 1904.

Mr. W. F. E. Adams, Extra Assistant Superintendent, 5th grade.

Mr. M. J. Sheehan, Extra Assistant Superintendent, 6th grade.

Mr. C. C. Byrne, Sub-Assistant Superintendent, 1st grade.

Mr. H. A. Gibson, " 2nd grade, died 12th August 1904.

Mr. B. C. Newland, " 3rd grade.

57 Surveyors and sub-surveyors and 2 writers.

working in the South Canara district (Southern circle).

(3) Mr. C. C. Byrne with 16 surveyors, sub-surveyors and apprentices, working in the Kurnool district and, towards the end of the season, in the southern portion of that of Kistna (Northern circle).

(4) Surveyor Balaji Dhondiba with 4 sub-surveyors working on revision surveys in the North Coimbatore district (Southern circle).

In addition to the above, Mr. Sheehan was employed independently on triangulation in Godávari, and Mr. Gibson and one recorder on similar work in the Trichinopoly and Chingleput districts. Triangulation and theodolite traversing were also carried out by some of the native surveyors working under the camp officers.

139. The various camps of the party, with the exception of the Coimbatore camp, left recess quarters in Bangalore early in November 1903 and, after a full working season of six months, closed field work in May 1904. The Coimbatore camp was detained in recess quarters for the purpose of completing mapping and did not take the field till 9th December 1903, returning to Bangalore about the 7th June 1904.

140. An area of 1,000 square miles was triangulated in Godávari, and a further area of 220 square miles in the Trichinopoly and Chingleput districts. In South Canara 428 square miles of triangulation in continuation of the work of previous seasons were completed, and in Kistna, 289 square miles. Two hundred square miles of reconnaissance in advance of triangulation was carried out in the North Malabar district, towards the close of the season. Most of the triangulation in Godávari, and the whole of that in Trichinopoly and Chingleput, was executed by Mr. Sheehan, and Mr. Gibson, respectively. Elsewhere native agency was employed with results that have proved generally satisfactory.

141. 247 linear miles of forest boundaries were traversed in Ganjam, Godávari, South Canara and North Coimbatore. The outturn in this respect is less than that of last year, but has been purposely reduced as leading to unnecessary expense. The area topographically surveyed on the scale of 4 inches to a mile amounts to 803 square miles, but includes some 96 square miles of resurvey of former seasons' work in North Coimbatore. Much of this area had to be surveyed by means of the chain owing to the density of the forest and undergrowth. This was especially the case in Godávari, and the flatter parts of South Canara and North Coimbatore. The work was rigorously tested throughout with satisfactory results.

142. The country in which the work was carried on during this year presented much the same difficulties as that surveyed in former years, except that in the Godávari district they were accentuated by the extreme deadliness of the climate. The health of the party generally was bad, and in Godávari district the percentage of days of sickness to days of work among the European assistants and native surveyors only, excluding menials, which in other districts varied from 3 per cent to 7·8 per cent, rose to 16 per cent. The abnormally heavy rain which fell over nearly the whole of Madras late into November 1903, may perhaps have had something to say to these heavy percentages. The labour difficulty,

138. As in previous years, the party was divided into camps, the constitution of each being as under:—

(1) Mr. G. T. Hall with one assistant and 18 sub-surveyors and apprentices, working in the Godávari district (Northern circle).

(2) Mr. W. F. E. Adams with 16 surveyors, sub-surveyors and apprentices,

too, in Godávari assumed an acute phase, as local labour was found almost improcurable and the imported labour would not stay to face the unhealthiness of the climate. The South Canara district, as usual, also proved unhealthy. Only one member of the party, Mr. H. A. Gibson, has died during the year, but there has been a heavy loss from invalidings, both in the permanent and temporary establishments, and a number of native sub-surveyors have resigned. The effects of sickness, chiefly malaria, contracted during the field season have been severely felt throughout the recess season, and have seriously interfered with the progress of mapping. Latterly, the recrudescence of bubonic plague in Bangalore has interfered with the work of the party, as the native members of the party living in the bazars have constantly to be subjected to segregation.

143. During the recess the computation of the whole of the arrears on triangulation and traversing was completed, as also that of all current traversing, and a great part of the current triangulation. Thirty-two sheets, including 19 sheets partially drawn last year have been mapped. Owing to incomplete verification of forest boundaries, 4 sheets of the Cuddapah district, 9 sheets of Kurnool, 1 sheet of South Canara and 4 sheets of North Coimbatore, have been withheld from publication, while 3 sheets of the Cuddapah district have been submitted for publication as provisional issues pending settlement of boundaries under dispute. The demarcation of the South Canara-Mysore boundary is still pending, but will be undertaken during the ensuing field season, and when complete, the boundary will be surveyed.

144. The following table shows the cost-rates of the different classes of survey, and the areas surveyed for the year under report and for the two preceding years. The decrease in area and increase in cost-rates during the former are due, partly to the excessive unhealthiness of certain districts as noted above, partly to the fact that in South Canara, owing to the want of definite information as to forest survey requirements on which to frame a consistent programme of work, the survey of small scattered areas has had to be carried out, and also to the fact that a considerable charge on account of the mapping of arrears in the Cuddapah district has had to be incurred. The final cost-rate of outturn during the current year, based on its cost-rate of topography and mapping, added to the cost-rates of triangulation and traversing from previous years for the areas involved, works out to **R 121-1-4** per square mile.

Description of survey.	OUTTURN.			COST-RATES PER MILE.		
	1901-02.	1902-03.	1903-04.	1901-02.	1902-03.	1903-04.
Triangulation	Sq. miles 1,680	Sq. miles. 2,030	Sq. miles. 1,937	R 5	R 5	R 9.2
Traversing	414*	538*	247*	14	13	19.5†
Topography, 4 inches = 1 mile .	1,306	1,411(a)	803	59	58	102.2

(a) Includes revision survey.

* Linear miles.

† Per linear mile.

145. The programme for the ensuing season comprises the continuation of triangulation in Ganjam, Godávari and South Canara, and the commencement and completion of the same in North Malabar. A small amount of theodolite traversing will be carried out in Godávari, and if the demarcation of the South Canara-Mysore boundary be sufficiently advanced during the season, this will also be traversed with the theodolite. The 4-inch detail survey will comprise the completion of the survey of forests of South Canara and North Coimbatore, the commencement of those in Ganjam and the execution of some 300 square miles in Godávari and 10 square miles in the Kistna district.

146. The nomenclature of the party has been changed with effect from 1st September 1904, from Nos. 9 and 19 Parties (Madras Forests) to No. 19 Party (Madras Forests).

147. The season's work has been verified with the aid of the Government notifications by the District Forest Officers of Godávari, South Canara, Kurnool and Kistna, who visited the recess quarters for the purpose.

148. The party was inspected during September by Major Symonds, I. A., Officiating Superintendent, Forest Surveys, and by Colonel Hobday, Deputy Surveyor General, on behalf of the Surveyor General.

BURMA.

NO. 20 PARTY.

149. The party left Dehra Dún on the 12th November 1903 and commenced field work in Burma on the 10th December.

Personnel.

Captain A. Mears, I. A., Officiating Deputy Superintendent, 2nd grade, in charge.

Mr. P. F. Prunty, Extra Assistant Superintendent, 3rd grade.

Mr. S. S. Mc'Afee Fielding, Sub-Assistant Superintendent, 2nd grade.

Mr. J. H. Williams, " 2nd grade.

Munshi Amjad Ali, " 3rd grade.

73 Surveyors, sub-surveyors, computers, and writers, etc.

ments under the charge of the following assistants and surveyors:—

- (1) Mr. P. F. Prunty with 10 traverse sub-surveyors and 6 computers in the Lower Chindwin, Yaw, and Myittha forest divisions.
- (2) Mr. S. Fielding with 10 sub-surveyors in the Upper Chindwin and Myittha divisions.
- (3) Mr. J. H. Williams with 6 sub-surveyors in the Lower Chindwin division.
- (4) Munshi Amjad Ali with 12 sub-surveyors in the Myittha and Yaw divisions.
- (5) Surveyor Sharf Uddin with 7 sub-surveyors and 1 computer in the Theyetmyo division.
- (6) Surveyor Maung Kyaw Nyein with 5 sub-surveyors in the Myittha division.

In addition to the above there were 8 probationers attached to the various camps for instruction and training.

151. Subsidiary triangulation in continuation of last season's work, based on the Manipur minor meridional and Mandalay minor longitudinal series, was carried out over an area of about 610 square miles by Mr. Prunty.

152. The country, as in previous seasons, was thickly wooded, and to allow of the topographical details being correctly surveyed, theodolite traverses had to be extensively used as formerly. Nine hundred and forty-eight linear miles of traverse were completed, representing an area of about 670 square miles, which is slightly under that of the estimated traverse programme. The theodolite was set up on an average 16 times per mile. The majority of the traverses were computed and proved in the field.

153. An area of 671 square miles, was surveyed topographically on the 4-inch scale in the reserves of the Upper and Lower Chindwin, Myittha and Theyetmyo forest divisions. The country presented much the same difficulties as reported in the previous season, and consequently the slow and laborious method of plane-table traversing had to be adhered to.

154. The total expenditure on survey operations for the year ending 30th September 1904 is Rs 1,39,510, as compared with Rs 1,48,468 for the previous year. The decrease is due principally to the absence of heavy arrears of mapping and publication charges, the transfer of two more or less highly paid assistants from the party, and a slight decrease in the subordinate establishment.

155. The following tabular statement shows the outturn and cost-rates for the year under report and the two previous seasons :—

DESCRIPTION OF WORK.	OUTTURN IN SQUARE MILES.			COST-RATES PER SQUARE MILE.		
	1901-1902.	1902-1903.	1903-1904.	1901-1902.	1902-1903.	1903-1904.
Triangulation . . .	250	1,161	610	R	R	R
Traversing . . .	1,646(a)	1,173(a)	948(a)	53·5(b)	44·7(b)	44·5(b)
Topography, 4 inches = 1 mile.	724	623	671	122·3	136·6	135·7

(a) Linear miles of traverse.

(b) Cost-rate per linear mile.

The triangulation cost-rate is higher than that of last year, the increase being due to the smaller area triangulated ; it may be noted, however, that nearly twice the number of points have been fixed.

The general cost per square mile for 4-inch topographical survey remains almost the same as for last season. The failure to reduce this somewhat high rate must be mainly ascribed to the difficult nature of the country under survey. Thickly wooded, high, and precipitous hills, intersected by deep valleys in which the undergrowth and vegetation was of the densest, necessitated the exclusive use of plane-table traverses, so that the outturn of even the best surveyors was necessarily small. The move of one camp during the field season, and heavy and unusual rain early in April, also tended to raise the cost-rate. It can hardly be expected to reduce this cost while the party continues to work in similar country.

156. The health of the party was fairly good until the end of March, when heavy and continuous rain caused a great deal of sickness amongst the native establishment. One sub-surveyor was sent on medical leave, ten *khalásis* died of fever and dysentery and one was drowned.

Supplies were not easily obtainable, and large quantities of rice had to be bought and stored at various centres in the areas under survey. The rationing of these food depôts was by no means easy, owing to the small number of Government elephants available for the purpose.

157. The examination of the area surveyed topographically shows the quality of the work to be satisfactory, no plane-table sections requiring revision. The testing was in the proportion of one linear mile to 1·93 square miles of detail survey.

158. The triangulation and traverse computations have been completed during the recess months, and the mapping of the current season's work will be completed before the party takes the field. The number of sheets submitted for publication during the year under report is 41, which includes 5 sheets of the previous season's work and 8 sheets of arrears mapping. There are now no arrears of mapping in the party.

159. The programme for 1904-05 is as follows :—

- (1) Triangulation and traversing in the forest reserves of the Lower Chindwin and Yaw divisions.
- (2) Topographical survey on the 4-inch scale in the Myittha, Yaw, and Lower Chindwin divisions.
- (3) Traversing in the Prome and 4-inch detail survey in the Thayetmyo division.

160. The Superintendent, Forest Surveys, inspected the party in the field during the month of January and in recess in August.

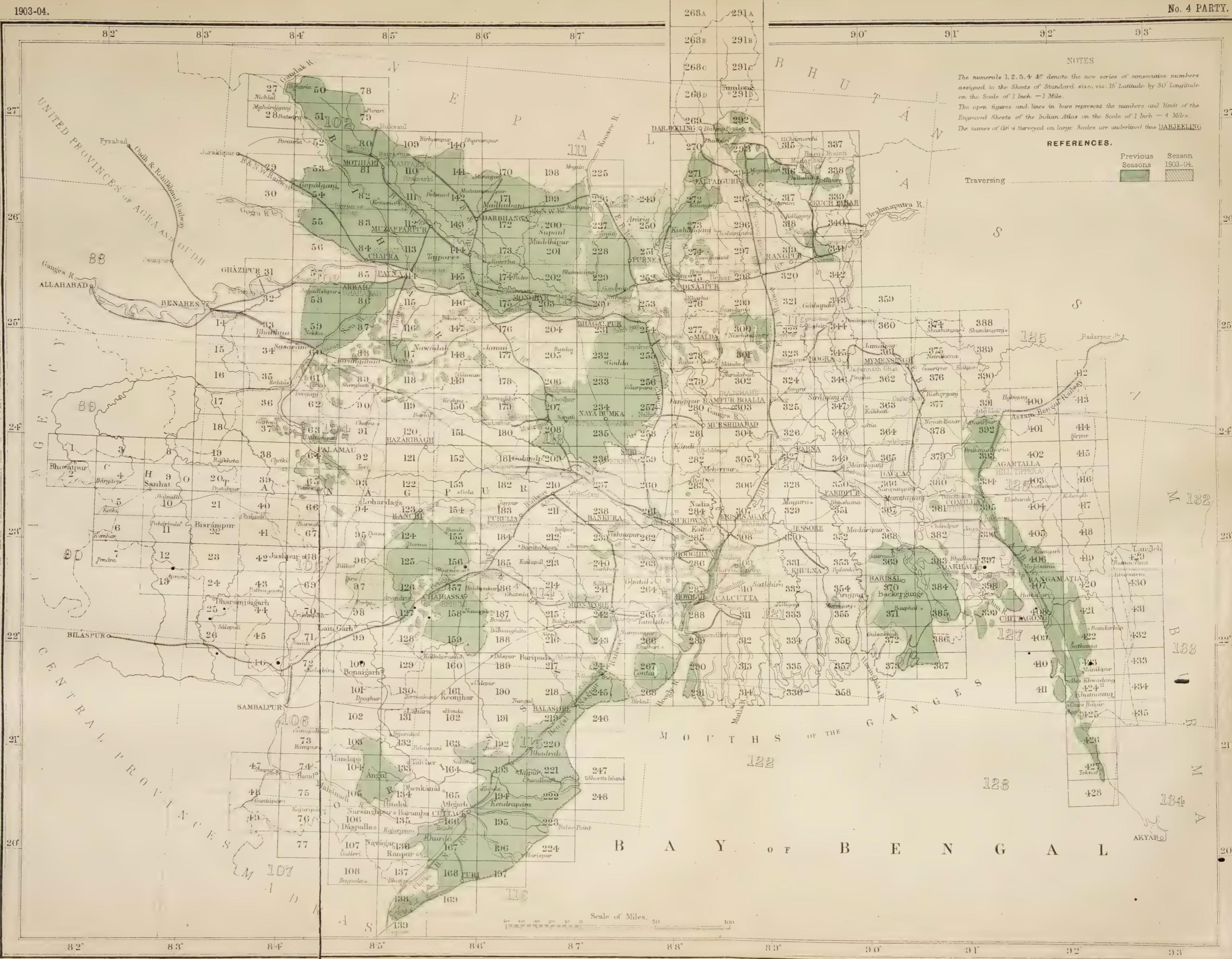
THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

BENGAL.

INDEX TO TRAVERSE SURVEYS.

1903-04.

No. 4 PARTY.

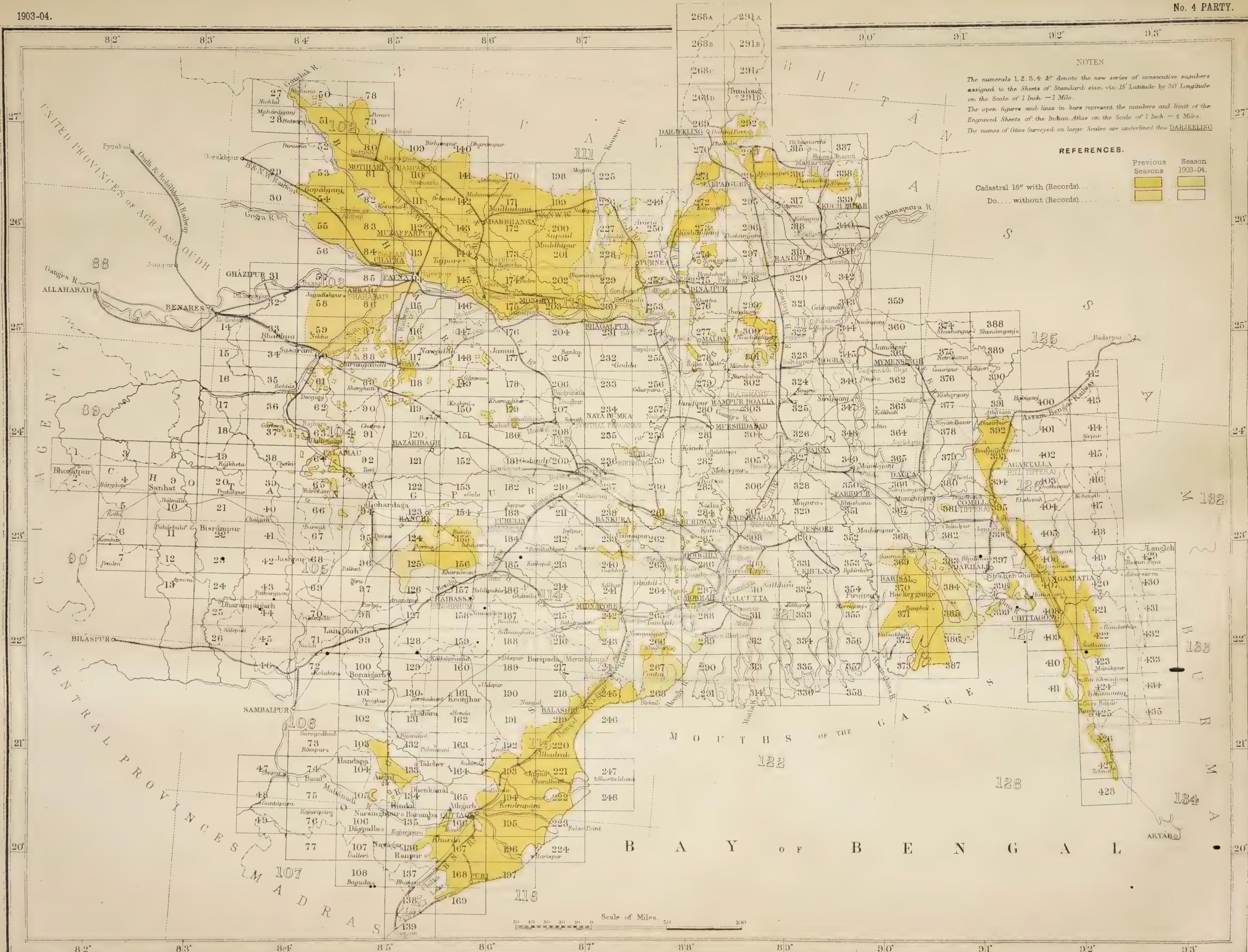


BENGAL.

INDEX TO CADASTRAL SURVEYS.

1903-04.

No. 4 PARTY.



CADASTRAL AND TRAVERSE SURVEYS.

BENGAL.

NO. 4 PARTY AND 6 DETACHMENTS.

161. The operations in Bengal remained under the supervision of Major R. T. Crichton, I. A., Superintendent of Provincial Surveys, except for 5 weeks (from 1st October to 9th November 1903) when he was on leave and Captain F. C. Hirst, I. A., officiated for him. The outturn of the season is :—

	Square miles.
Traversing	5,028
Cadastral survey	4,054
Record-writing	4,065
Topographical survey on the scale of 4 inches = 1 mile	463

This is the largest outturn in one season that has yet been accomplished. The programme was fully completed except in Ránchi and Midnapore districts, which was, however, more than counterbalanced by excess areas obtained elsewhere.

162. *Midnapore district.*—The operations consist of the cadastral survey with record-of-rights of the

Personnel. Mr. C. S. Gasper, Extra Assistant Superintendent, 5th grade, in charge. Jalámútha, Májnamútha,

Mr. P. F. Delaney, Sub-Assistant Superintendent, 2nd grade. Balarámpur and other scattered estates which had been

2 Supervisors, 32 inspectors, 353 amins 13 computers, drafts- men, etc., 363 moharrirs. traversed during the previous season. The traversing consisted of the completion of some arrears and of the Jámirápál estate which was an addition to the original programme. The outturn was :—

	Square miles.
Traversing	22
Cadastral survey	621
Record-writing	486

As the records were not completed of the whole area surveyed it is impossible to give a cost-rate, but the scattered nature of the work points to a probable high one.

163. *Bhágalpur district.*—The outturn and cost-rates per square mile, are :—

	Area in square miles.	Cost-rates per square mile.
	<i>R</i>	
Traversing (<i>mauzawar</i>) for cadastral survey	168	35·8
Traversing for topographical survey	300	25·6
Cadastral survey	275	56·6
Record-writing	282	26·1
Topographical survey, 4 inches = 1 mile	297	16·8

The area surveyed topographically includes 10 square miles of the Sonthal

Parganas and consists of portion of the beds of the Ganges and Kosi rivers known as *diára* lands which it has been decided to survey in future on the 4-inch instead of the 16-inch scale. All topographical items such as rivers, roads, village sites (in blocks) and the larger patches of cultivation have been mapped. The village boundaries were not surveyed, but have been taken from the Revenue survey maps of

Captain F. C. Hirst, I.A., Assistant Superintendent, 1st grade, in charge to 29th February, 1904.

Lieut. L. C. Thuillier, I. A., offg. " 1st " in charge from 1st March 1904.

Mr. H. A. Hardless, Sub- 3rd " 1 Supervisor, 41 sub-surveyors, 33 computers, etc.

Cadastral.

Mr. A. W. Smart, Extra Assistant Superintendent, 1st grade.
 " C. S. Kraal, 3rd "
 " P. L. Causley, Sub- 1st "
 " O. J. H. Hart, 2nd "
 " O. E. C. Judd, 2nd "
 " G. W. Archer, 3rd "
 " I. Newton (proby.), 3rd "
 4 Supervisors, 68 inspectors, 600 amins, 45 draftsmen, 300 moharrirs.

1846-48 and shown on the maps in red. The Government and temporarily settled estates situated in the *diára* lands were surveyed cadastrally, reduced by pentagraph and entered in the maps to make each sheet complete. There were 4,981

theodolite stations in the area traversed, of which 415 have been marked by stones, 246 by cylinders and 4,320 by wooden pegs.

The cost-rates for the traversing are high because the cost of moving the establishment into the field all falls into the expenditure under this head, the traversing having occupied the earlier portion of the field season. Also the area traversed is a small one which always means high cost-rates. The total cost-rate, R82·7 for cadastral survey and record-writing, is very low and is attributable principally to the large size of the fields which average 1·3 acre, but also to the fact that the Bihár establishment is now highly trained.

164. Purnea district.—The operations in this district were of the same nature as those in Bhágalpur and were carried out simultaneously by the same establishments, the outturn and cost-rates being:—

	Area in square miles.	Cost-rates per square mile.
	<i>R</i>	
Traversing for cadastral survey	1,997	26·6
Traversing for topographical survey	183	16·4
Cadastral survey	1,499	64·9
Record-writing	1,499	36·6
Topographical survey, 4 inches = 1 mile	166	13·5

The traversing was connected with 9 stations of the Great Trigonometrical survey, there were 38,812 traverse stations marked by 4,491 stones, 30,769 clay cylinders and 3,552 pegs, the latter having been used in the 183 miles of *diára* lands which were traversed for topographical survey.

The comparison of village boundaries with the Revenue survey maps of 1842-48, disclosed few changes of any importance except in the Kosi *diára* tract. There were 521 boundary disputes. All the maps and records were completed in every respect and the records and 3 printed copies of each of the maps were furnished to the Settlement Department.

The cost-rate of the *mauzawar* traversing is slightly higher than that of last season which is attributable to the smaller average size of the villages. The rate for traversing for topographical survey is fair considering this is the first season the establishment has been employed on this kind of work, but it is expected that in future it will not exceed R12 per square mile. The combined rate for cadastral survey and record-writing is very low and is due to large fields (1·1 acre), large and compact programme, and a fully experienced establishment. The outturn of cadastral survey given above does not include the overlap along the Srinagar-Baneli estate boundary, the necessity for which has been explained in former reports, nor does it include the resurvey of 905 scattered holdings of that estate, aggregating 2,480 acres, which were found to be out of position and configuration.

165. Backergunge district.—The operations consisted of the completion

Personnel.

Traverse.

Mr. C. H. G. Johnson, Extra Assistant Superintendent, 5th grade, in charge.

Mr. P. Kenney, Sub-Assistant Superintendent, 2nd grade.

28 Surveyors, 17 computers, etc.

Cadastral.

Mr. N. Bedford, Extra Assistant Superintendent, 4th grade, in charge.

Mr. E. G. Hardinge, Sub-Assistant Superintendent, 1st grade.

Mr. F. W. Marten, Sub-Assistant Superintendent, 2nd grade.

Mr. A. B. Smart (Jr.), Sub-Assistant Superintendent, 2nd grade.

Mr. T. F. Kitchen (proby.) „ „ Superintendent, 3rd grade.

1 Supervisor, 45 inspectors, 550 *amans*, 7 computers, draftsmen, etc.

included in the outturn which is given below together with cost per square mile.

	Area in square miles.	Cost-rates per square mile.
	<i>R</i>	
Traversing	843	57·1
Cadastral	876	96·5
Record-writing	963	30·9

There were 22,730 traverse stations of which 2,030 are marked with stones and the remainder with wooden pegs. Azimuth observations were made at 150 stations. The establishment of foreign *amins* that had hitherto been employed was reduced this season to 7 Inspectors and 28 *amins*, the cost-rate of the traversing is R13 higher than it was last season, and is due both to the small area traversed, and to the difficult nature of the country. Two large swamps or *bhils* which rendered the erection of the theodolite a matter of some difficulty were encountered and a part of the area traversed is intersected by numerous small rivers, and crowded with scattered homesteads surrounded by palm trees, which necessitated very short traverse lines. The swamps were inhabited by wild buffaloes, of which the surveyors were in much dread. The record cost-rate is not quite final as the statistical statements of 26 villages were not completed at the end of the season, but the combined rate for cadastral survey and records cannot exceed R130, a satisfactory reduction on that of last season which is chiefly due to the firm and good management of Mr. Bedford.

166. *Ránchi district*.—The operations in Ránchi were in continuation of those of last season and the outturn and cost per square mile were :—

	Area in square miles.	Cost-rates per square mile. R
Traversing	861	32·0
Cadastral survey	748	57·8
Record-writing	801	35·4

The season's traversing was connected with 2 stations of the Great Trigonometrical survey and the angular work was checked by observations for azimuth at 184 stations. The total number of theodolite stations is 20,077, of which 14,230 were marked with stones, 1,674 with a broad arrow cut *in situ* and 4,173 with wooden pegs. The cadastral survey includes a compact block of 34 square miles which was surveyed by *amins* who were under training. The writing of the records of the area of 179 square miles which remained over from last season was completed, but that of 91 square miles surveyed this season still remains to be done. Half the area surveyed cadastrally consisted of wooded hills with scattered patches of cultivation, the positions of which had to be fixed by plane-table intersections through dense jungle, and across ravines where chaining was impossible, but notwithstanding these difficulties and the poor average daily outturn of the *amins*, the cost-rates are very low, as cooly labour was supplied free.

167. *Singhbhum district*.—The operations in this district were carried out by the Ránchi establishment and consisted of the traversing of the Saraikela and Kharsawán estates, the area traversed being 600 square miles, of which about one-fourth is hilly and jungle-covered country. Out of 14,420 theodolite stations, 1,518 were marked by trijunction stones, 10,666 by ordinary stones, 1,839 by wooden pegs and 397 were cut *in situ*. The cost per square mile is R33·6.

168. *Calcutta Municipality*.—The survey of the added area of the Calcutta municipality on the scale of 50 feet to the inch was continued under Mr. R. B. Smart (retired). The area is 8,443 acres, but the survey of the adjoining area of the Panchánnagram Government estate has also been decided on and will be done in conjunction with that of the Calcutta suburbs. This additional area is 2,207 acres, of which 313 are to be surveyed on the scale of 1 inch=50 feet and the balance on the scale of 32 inches=1 mile. The outturn for this season is :—

	Acres.
Traversing	4,513
Detail survey	5,561
Record-writing	4,850

These figures added to those of last season show that 2,934 acres remain to be traversed and 1,111 acres to be surveyed in detail on the larger scale, and

1,762 acres on the smaller scale, while the records of 5,653 acres remain to be written. As no branch of the work is as yet complete, no cost-rates have been calculated.

169. *Bhágalpur Municipality*.—This survey with record-of-rights has been continued by one of the Bihár cadastral camps under Mr. Kraal. The total area is 12 square miles containing 3,371 holdings. The congested area, aggregating 1·3 square mile, was surveyed on the 64-inch scale on 23 sheets, and the balance on the 16-inch scale on 21 sheets. The municipal holding was taken as the unit of survey and given a number, while all items within the holding, such as tanks, houses, etc., were given separate letters. The expenditure was R 306 for traversing and R 7,857 for detail survey and record. Owing to a severe outbreak of plague the establishment had to be withdrawn from 23rd March to 14th June.

170. *Monghyr Municipality*.—The survey with record of this municipality was undertaken by No. 4 Party (Bihár) at the request of the Municipal Commissioners and the expenditure was met by them. The congested portions only were surveyed on the 64-inch scale and the rest on the 16-inch. The total area surveyed was 3,680 acres, of which 910 were surveyed on the 64-inch scale. The total number of holdings was 18,266 and the average size of the holdings in the congested area was '07 acre, and in the other portion was '52 acre. Only the field work and mapping were completed, as the survey was carried on during the recess, and was much retarded by heavy rains and plague. The expenditure to the end of the season was R 2,675.

171. *Miscellaneous surveys*.—The following minor surveys were also carried out under the Superintendent, Provincial Surveys.

(1) The re-traversing and demarcation of the boundary of *Mauza* Karaulia Bhasauli in the Bettiah sub-division of Champaran district.

(2) The re-laying of the boundary of *mauza* Darobast in the Monghyr district.

(3) The re-laying of the northern boundary of *mauza* Ghora *urf* Katora in the Patna district.

(4) The cadastral survey with record of *mauza* Chaparsan in the Darbhanga district.

(5) The completion of the survey on the 64-inch scale with record of the Roserha Municipality in the Darbhanga district.

(6) The traversing of the boundary of the Udaipur State, Chota Nagpur. One-half only was traversed this season.

BENGAL DRAWING OFFICE.

172. The outturn of work in this office during the season has been far in excess of that of any previous season and as the work is still increasing, the office will shortly be moved into more commodious quarters.

Standard maps.—The 4 remaining sheets of Orissa have been completed and submitted for publication, also the 14 sheets of Chittagong and the following have been published:—sheets 135 to 137, 165 to 167, 169, 192, 194 to 197 and 219 to 223 of Orissa; sheets 409, 410, 411, 420, 423, 424 and 428 of Chittagong. Of Bihár the following sheets have been submitted for publication, Nos. 50, 78, 141, 142, 144 and 198 and sheets Nos. 84, 85, 109, 110, 112, 113, 114, 140 and 198 have been published during the season. The 9 sheets comprising the Darbhanga district are well advanced and will be published shortly.

District and Thána maps.—District maps of Muzaffarpur and Balasore have been completed and sent for publication on the $\frac{1}{4}$ -inch scale. That of Sáran has been completed, but publication is delayed on account of recent changes in boundaries. Those of Cuttack and Puri are in hand and the question of the preparation of the district map of Chittagong is under consideration as no material is available from recent surveys for a great portion of the district. The compilation of the Champaran district map awaits the publication of standard sheets 50 and 78 which have only just been sent for publication. All the *thána* maps of Orissa have been published with the exception of 1, while the 2 of Bihár that remained from last season should be ready for publication in October 1904. Those of Darbhanga could not be taken in hand, as none of the

standard sheets of that district have been published yet. Of Chittagong, the maps of 5 out of the 13 *thánas* have been published and those of the remaining 8 *thánas* are in hand.

Reproduction of village maps.—With the exception of 20, all the sheets of Orissa have been printed and 10 copies of each issued; the tracing of all the Sáran sheets has been completed; 5,389 sheets were traced during the season, 4,103 have been reproduced and 30,000 copies have been furnished to the Collector. A commencement has been made with the reproduction of the sheets of Muzaffarpur of which there are 6,560 and 10 copies of each are required; 2,000 have been traced only. In the Backergunge district 150 printed copies of each sheet have been asked for. This has necessitated a still further increase in plant. During the season 789 sheets were traced, 497 were reproduced and 18,172 copies furnished to the Settlement Officer. Copies of the whole of the sheets of the first season's survey in this district, 1,050 sheets, will be supplied by the end of November 1904.

173. The system of reproducing village maps by the Vandyke process has been extended to the copies required at the attestation stage of settlement, as the field map is now drawn on paper which admits of reproduction by this process direct without the intervention of a trace. This procedure is found to be more economical than the system of preparing traces, as no examination is required. Three copies are supplied and are stamped "not final" to prevent the danger of their being mixed up hereafter with copies of the finally corrected sheets which will be supplied later on in the usual course. The number of sheets of the current season's work which were to be so dealt with was 6,648 but as this was more than the office could cope with, it was decided to print 4,429 sheets only, and prepare traces of the rest. During the season 5,558 copies were reproduced of 2,873 sheets. The balance will be completed during the early part of next field season.

174. The preparation of traverse charts on the scale of 1 inch=1 mile for the whole of the Bengal surveys has been commenced in accordance with Departmental Order (Professional) No. 19, dated 21st January 1902. Up to date only the computations of the co-ordinates of 3,445 villages of Muzaffarpur and 1,075 villages of Darbhanga have been completed. The Board of Revenue have also ordered the preparation of similar maps and a commencement has been made with those of Patna, Gaya and Shahabad, of which 4,695 villages have been plotted.

175. From the commencement of next season the 5 field detachments will be formed into 2 parties and numbered 5 and 6. The programme is as follows:—

Party.	District.	Traversing for cadastral survey.	Cadastral survey.	Record writing.	Topographi- cal survey 4 inches= 1 mile.	Traversing for topogra- phical survey.
4	Bhágalpur	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.	Sq. miles.
	Purnea	1,258	40	40	85	...
5	Midnapore	711	1,633	1,633	176	...
	Ránchi . . . .	...	21	135	...	...
6	Singhbhum	1,630	887	1,012	...	...
	Backergunge	200	1,027	1,027	250	250
	Faridpur	1,600	...	...	...	...
24-Parganas (Sundarbans) . . . .		...	...	...	300	300
Totals . .		5,399	4,208	4,447	811	550

176. Major Crichton inspected each camp or detachment, on an average twice during the field season and again during the recess.

UPPER BURMA.

NO. 7 PARTY.

177. The operations of this party were confined for the season to Upper

Personnel.

Lieut.-Colonel G. B. Hodgson, I. A., Superintendent, 1st grade, in charge from 8th March 1904.

Captain C. P. Gunter, R.E., Officiating Deputy Superintendent, 2nd grade, in charge from 13th October 1903 to 7th March 1904.

Mr J. S. Swiney, Extra Assistant Superintendent, 2nd grade.

Mr. O. D. Smart, " " 4th "

" C. Graham Lee, " " 5th "

Babu Jagdamba Prasad, Officiating Extra Assistant Superintendent, 6th grade.

Babu A. C. Bose, Sub-Assistant Superintendent, 1st grade.

Mr. W. E. Swiney, " 3rd "

17 Traverse sub-surveyors, 13 computers, 21 draftsmen, typers and estimators, 7 inspectors and 69 field surveyors.

Burma and were in continuation of those of the previous season in the districts of Pakôkku and Shwebo. The programme originally included the survey on a large scale of the added area of Rangoon, which, however, had to be postponed as it was

found that no demarcation had been done by the local authorities. The establishment that had been assembled for the Rangoon town survey was, therefore, transferred to the Pakôkku district and employed on both traverse and cadastral work. In connection with the preparations made for the Rangoon town survey, there was an expenditure of R4,163 incurred in moving the establishment to Rangoon from Mandalay and thence back to Pakôkku.

178. The programme for the season was otherwise completed and the outturn is as follows :—

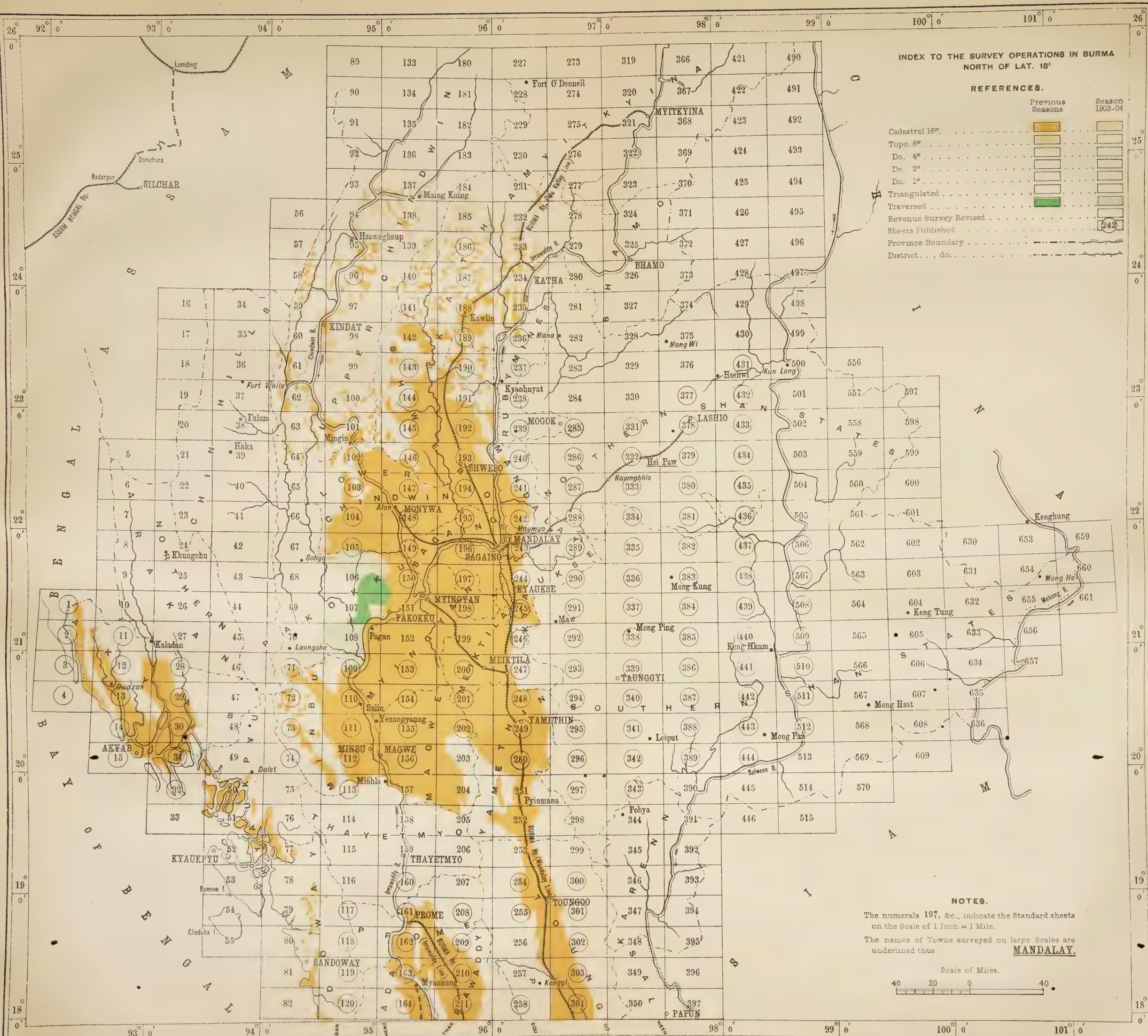
District.	TRAVERSE SURVEY.					CADASTRAL SURVEY, 16 INCHES=1 MILE.					
	No. of kwins.	Square miles.	Cost per square mile.	No. of kwins.	No. of sheets.	No. of fields.	Acres.	Square miles.	Cost per square mile.	Average size of field.	
			R						R	Acre.	
Pakôkku	393	630	60	198	389	133,439	190,932	293	274	1'09	
Shwebo	189	229	107	389	748	75,396	332,009	520	691	0'52	
TOTAL	582	859		587	1137	208,835	523,541	818			

(a). Includes 65 square miles of river circuit.

179. *Shwebo district.*—The traversing was carried out under the supervision of Mr. Lee. Field work commenced on the 13th October 1903 and at the end of January 1904 the programme in this district having been completed, the traverse camp moved into the Pakôkku district. The area traversed consisted almost entirely of uncultivated land covered with scrub jungle and was in places undulating and broken, and in some parts hilly. The average number of traverse surveyors employed was 12 for a period of 92 days. Each man's average daily outturn for working days was 11 angles and 134 chains. No main circuits were measured. The new work was merely connected on to the traversing done in 1891-94. Most of the old work had to be re-observed, as a large number of the station marks were found to have disappeared. Thus out of 2413 of the old stations that were utilised, new marks had to be embedded at 1981. With the exception of 14, all the village traverses closed satisfactorily and in those that did not, the error was introduced from the old work as repeated remeasurements showed. There were 2 origins in the old survey. The intersection of longitude 95°30' and latitude 22°30' for the Ye-u sub-division, and of longitude 96°00' and latitude 22°30' for the rest of the district. All the computations have been completed.

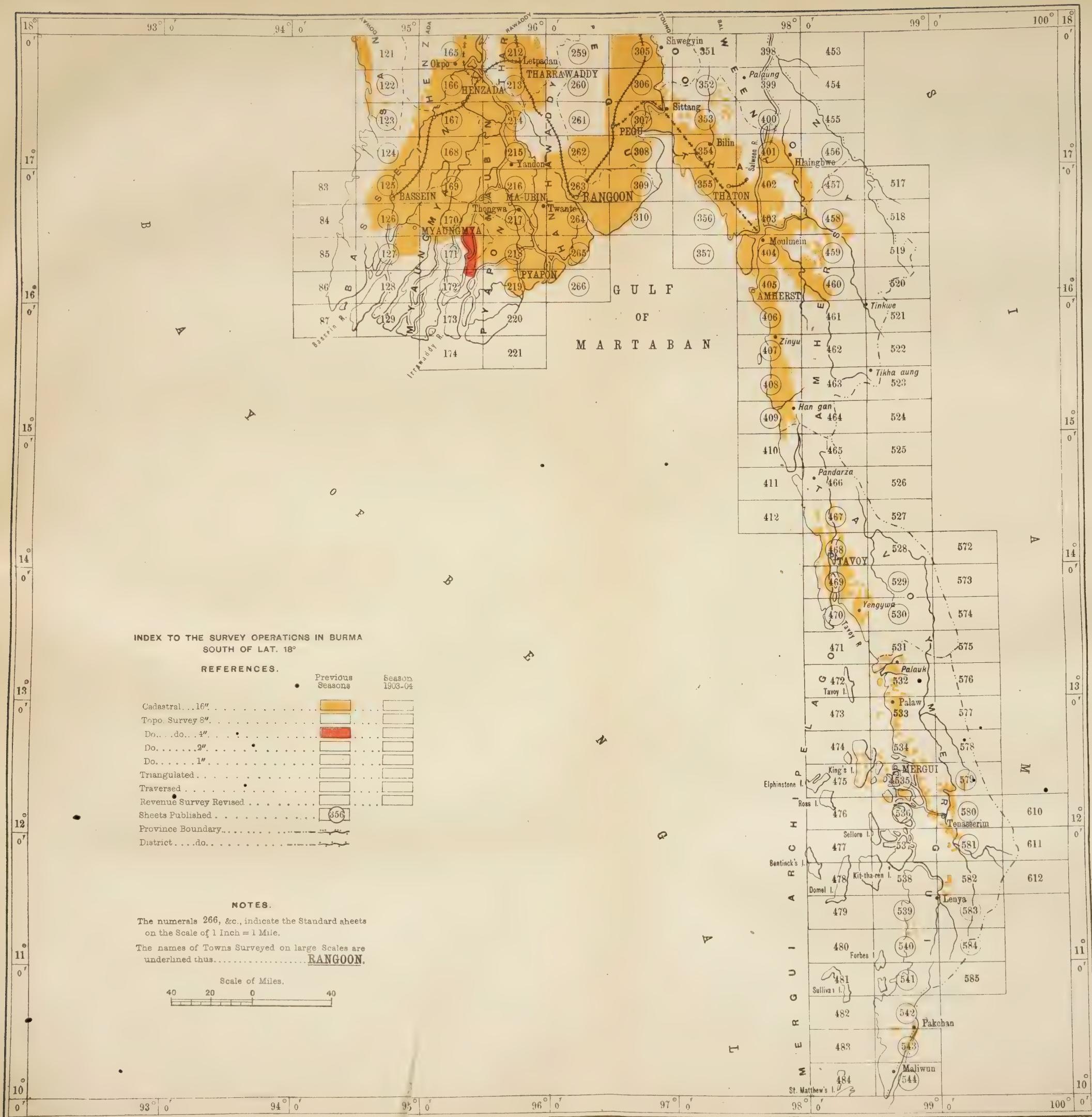
180. The cadastral survey was carried out under Mr. J. S. Swiney with Babu Bose and Mr. W. E. Swiney as his assistants. Field work commenced on the 13th November 1903 and closed on the 30th April 1904. The average number of field surveyors employed was 33 and 3 native inspectors. Twelve of the ámins were Burmans, whose outturn is seldom equal to that of natives of India. The new work mostly formed a fringe to the old survey and was scat-

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS



18°
0°
17°
0°
16°
0°
15°
0°
14°
0°
13°
0°
12°
0°
11°
0°
10°
0°

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS



tered in patches all over the district, some patches containing only one *kwin*, consequently a considerable amount of time was lost in moving *ámins* from one block to another. The total area that had been divided up into *kwins* was 520 square miles, but the greater portion of this area and many entire *kwins* contained no cultivation at all. All topographical details were mapped in and adjoining cultivation and elsewhere when forming *kwin* boundaries, but otherwise in waste land only the larger details were surveyed and the traverse lines were accepted as the *kwin* boundaries. The number of plots actually surveyed is 73,493 covering an area of 38,022 acres or 59 square miles which give 0·52 acre as the average size of the plot. The detail survey was tested by 312 linear miles of test lines by Imperial and Provincial officers and 97 linear miles of independent *partál*.

181. The fair mapping consisted of the insertion of the new detail on the 2-inch standard sheets compiled from the old survey. The additions are not sufficient to call for publication and the sheets will be forwarded to the headquarters office for record until required for supplementary survey. Of the 16-inch sheets, 151 comprising 68 *kwins* have been forwarded to Calcutta for reproduction, and 30 copies of each of these have been furnished to the Settlement officer together with the area statements of 235 *kwins*. Traces of all the 16-inch maps were also furnished to that officer at the request of the Local Government. Neither the fair mapping nor the field sheets were quite completed during the recess, because wherever the new work touched on the old, it was found that considerable changes had taken place since the former survey. As *kwin* boundaries were affected in most instances, all such cases had to be referred to the Settlement Officer for decision as to the boundaries. The number of *kwins* affected was nearly half the number surveyed. The old boundaries were seldom upheld, consequently the maps and area statements of the adjoining *kwins* of the old survey have to be revised, and this will be taken in hand as soon as the mapping of the current season's work is completed. The sub-division of the *kwins* of the former survey continues, but has not assumed large proportions in this district. The number of *kwins* sub-divided during this season is 3 and the total to date 31 on 47 sheets which have been divided into 61 *kwins* on 67 sheets. Others are in hand.

182. The cost-rate for the cadastral survey has been calculated on the area actually surveyed as explained at paragraph 180. The rates are of no value as the survey was of an exceptional nature and the cost out of all proportion to the work accomplished, owing to the large extent of country over which this small area of cultivation was scattered and to the heavy expenditure involved in transporting full establishments to and from the district for such a small operation as it proved.

183. *Pakókku district*.—The traversing of the Myaing township was completed and that of Seikpyu commenced. The general character of the country operated in was undulating and fairly open, but in some parts it was hilly and broken and covered with scrub, jungle. Water was scarce almost everywhere. One camp composed of 6 traverse surveyors under Mr. Smart commenced work on the 1st November 1903 and early in February, 11 more sub-surveyors under Mr. Lee, moved into this district after completing the programme in Shwebo. Field work closed on the 25th April 1904. The average number of days each traverse surveyor was employed is 126 and their daily average outturn during working days was 12 angles and 151 chains. The chain measurements amounting to 1,671 linear miles were checked by connection with 4 stations of secondary triangulation, but the results have not yet been computed as the triangulation was carried out this season also and the co-ordinate values of the stations have not yet been received. All the circuits, however, closed within the prescribed limits, with an average chaining error of 0·48 link *per mille*. The computations cannot be completed until the co-ordinates of the trigonometrical stations are received.

184. Two camps were employed on cadastral survey in this district. One under Mr. Smart commenced field work at the end of November 1903, under the circumstances narrated at paragraph 177, but the second under Mr. J. S. Swiney which had been working in Shwebo, did not break ground till the beginning of March 1904, and field work closed on the 10th May 1904. The average number of field surveyors employed was 36 for 160 days under 5 native inspectors.

The character of the survey was the same as in Shwebo and the nature of the ground much the same as that met with by the traversers with the exception of a narrow strip of highly cultivated land along the bank of the Irrawaddy. Of the 298 square miles that came under survey, 220 consisted of cultivated land containing 141,015 acres and 129,694 fields: these figures give 1.09 acre as the average size of the field and 24 acres and 22 fields as the average daily outturn of each *ámin*. The survey was checked by 362 linear miles of test lines by Imperial and Provincial officers and 35 linear miles of independent *partáls* averaging 1.8 linear mile to each square mile of the area actually surveyed.

185. All the fair mapping connected with the season's work was completed and one standard sheet No. 149 was sent to the head-quarters office for supplementary survey by No. 10 Party during the ensuing season. The drawing of sheets 150 and 151 was continued and completed as far as surveyed. These two sheets will be completed next season and will be available for supplementary survey the season after. Four new sections 105 S. E., 106 N. E., 107 N. E.-S. E., were projected and the season's work entered thereon. The original 16-inch maps of 90 *kwins* on 180 sheets have been sent to Calcutta for reproduction. The inking up and typing of all the rest has been completed, but they still require final examination.

186. The cost-rate for the traverse survey this season is much the same as usual, but that for the cadastral survey is exceptionally high. The latter rate is calculated on the area actually surveyed as given in para. 184, whereas in former seasons it has been taken from the whole area embraced by the operations. Following this procedure the rate comes to R200 per square mile which is still high and is due to the small outturn of one camp which had been originally told off for the Rangoon town survey and its native establishment had been considerably reduced. The average size of the field is somewhat larger than it was last year.

187. A sum of R1,605 is debitable to the Pakôkku town survey for the completion of the field sheets and area statements and preparing a wall map on the scale of 16 inches to the mile. The survey (which was done last season) was on the scale of 64 inches to the mile and occupied 7 *ámins* for an average of 80 days. The total area surveyed on that scale is 1,758 acres, of which 371 are occupied by houses. The number of plots is 9,980 and the total cost R5,034, which does not include the printing of the maps. This item will come to about R766 more and including this the cost-rate is R3.3 per acre. The field sheets have all been sent to Calcutta to be printed.

188. *Programme 1904-05.*—Next season the survey of the Pakôkku district will be continued; 600 square miles will be traversed in the Seikpyu and Pauk townships and 600 square miles cadastrally surveyed, completing the Myaing township. A survey on the scale of 100 feet to the inch will also be done for the Rangoon Municipality of an area of about 9 square miles of land recently added to the municipal area. This party will also take up the preparation of traverse charts for the whole area that has been cadastrally surveyed in Burma.

189. The Deputy Surveyor General inspected the party in February 1904.

UNITED PROVINCES OF AGRA AND CUDH.

NO. 8 PARTY.

190. The operations in these Provinces remained under the supervision of Captain W. M. Coldstream, R. E., Superintendent of Provincial surveys, throughout the year. The outturn accomplished consisted of—

Topographical resurvey	.	.	.	.	.	114 square miles.
Traversing	.	.	.	.	.	270 "
Cadastral survey	.	.	.	.	.	507 "
Cadastral map correction	.	.	.	.	.	1,488 "
Record-writing	.	.	.	.	.	1,894 "
Town surveys	.	.	.	.	.	5 "
Road surveys	.	.	.	.	.	1,125 linear miles.

Twelve standard sheets, three district maps, and two traverse charts were submitted for publication. The work was carried out by one traverse and three cadastral camps and one drawing office.

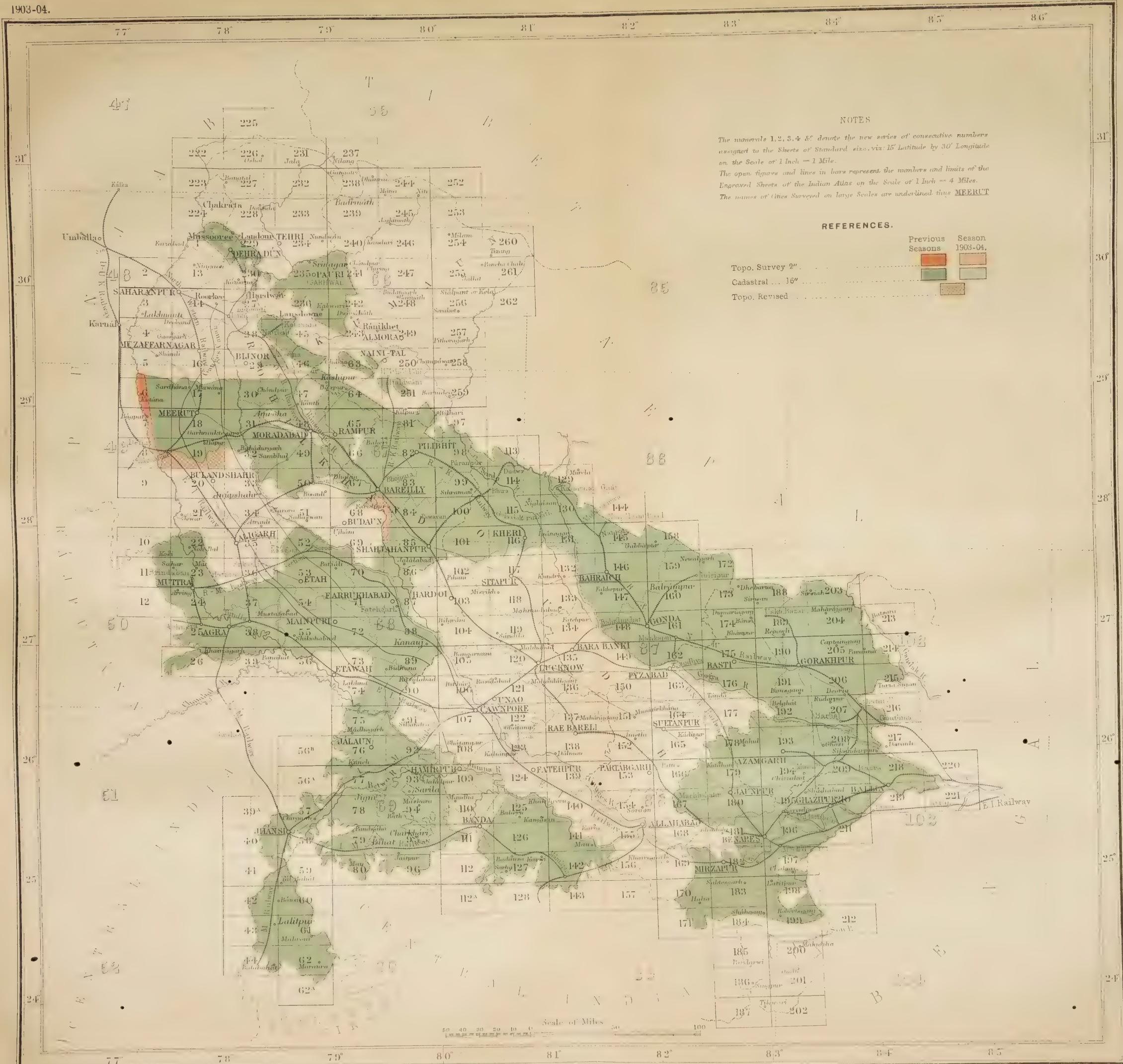
THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

UNITED PROVINCES.

INDEX TO CADASTRAL SURVEYS.

No. 8 PARTY.

1903-04.



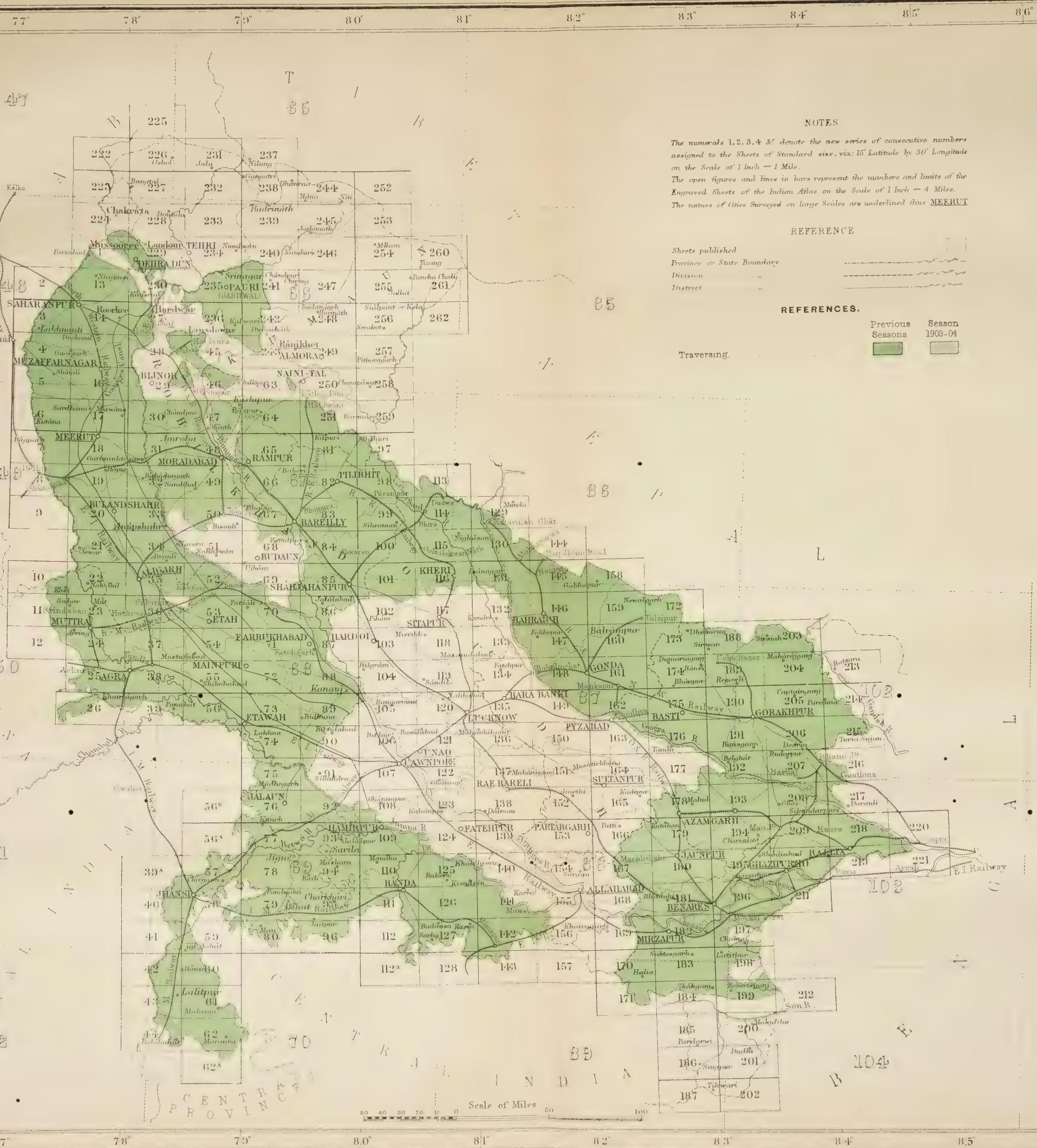
THE LIBRARIES
OF THE
UNIVERSITY OF ILLINOIS

UNITED PROVINCES.

INDEX TO THE TRAVERSE SURVEY.

No. 8 PARTY.

1903-04.



191. *Camp No. 1.*—In Moradabad, 269 square miles were traversed for *Personnel.*

Mr. F. S. Bell, Extra Assistant Superintendent, 5th grade, in charge.

5 Traverse sub-surveyors, 5 computers, 17 *amins*, etc.

along the high bank of the Ganges. The work was connected with three stations of the Great Trigonometrical survey, the errors so disclosed being 2·9 and 3·2 linear feet per mile. An area of 315 square miles in the alluvial tracts of the Ganges remains to be traversed next season.

192. The following towns were surveyed for municipalities on the scale of 64 inches to the mile.

	Sq. miles.
Muttra	2·86
Brindaban	1·17
Tanda Khas	·53
Barehta (Fyzabad)	<u>·23</u>
TOTAL	<u>4·79</u>

In Muttra and Brindaban, open ground was surveyed on the 16-inch scale and only the exterior limits of blocks of buildings were surveyed, while in Tanda Khas and Barehta, the whole area was surveyed on the 64-inch scale, and the interior limits of each house were also mapped. Record-writing was confined to certain columns of the field books and the preparation of area statements. The detail survey was based on a close net-work of traversing and was tested by an average of 12·3 linear miles and 57 acres of check survey per square mile. The cost-rate for the Tanda Khas work is Rs 4·7 per acre. As the other town surveys are still in progress, their cost-rates cannot yet be ascertained. The maps of Hatheras, Sikandra Rao, and Atrauli towns, surveyed last season, were completed and printed, the combined cost-rates for survey, mapping, and record-writing, being As. 8·6 per acre for 16-inch survey, and Rs 4·6 per acre for 64-inch survey.

The same camp also surveyed the boundaries and adjacent detail of 1,125 linear miles of first class roads in the Meerut and Lucknow divisions, for the Public Works department. The work was tested by 119·8 linear miles of check survey.

193. *Camp No. 2.*—Cadastral operations commenced in Moradabad in

Personnel.

Mr. L. F. Berkeley, Extra Assistant Superintendent, 3rd grade, in charge.

" J. H. Murphy, " 5th "

19 Inspectors, 270 *patwaris*, etc.

October 1903, and included an area of 593 square miles. Of this, 507 square miles, consisting of the alluvial tracts in Amroha,

Moradabad, and Thakurdwara *tahsils*, were surveyed, and the maps of 86 square miles in the sandy tracts of Amroha *tahsil* were revised and corrected. Preliminary records-of-rights were written for 527 square miles. A small area of 20 square miles, part of an addition made to the programme late in the season, was also traversed. The cost-rates were Rs 46·9 per square mile for cadastral work, and Rs 17·6 per square mile for record-writing. The maps were tested by an average of 5 linear miles of check survey, and 20 per cent of the *khasra* entries were checked on the ground. The average size of fields was ·7 of an acre. Of the 270 *patwaris*, 203 proved competent to survey their villages, 39 were allowed to provide their heirs to do their work, and substitutes had to be appointed for 28 for survey, the records being written by the *patwaris* themselves. The work remaining to be done in this district consists of the correction of the cadastral maps of 250 square miles in the Amroha, Hasanpur and Sambhal *tahsils* and the cadastral survey of 315 square miles in Hasanpur which will be completed next season.

94. *Camp No. 3.*—In the Banda district, work commenced in October 1903,

Personnel.

Mr. F. B. Powell, Extra Assistant Superintendent, 5th grade, in charge.

Babu Nilmoni Chatterji, Extra Assistant Superintendent, 6th grade.

16 Inspectors, 207 *patwaris*, etc.

and consisted in the revision and correction of the cadastral maps of Banda and Pailani *tahsils*, with the preparation of annual *patwari* records. As was foreseen,

when the operations were sanctioned, a considerable number of the villages had to be re-surveyed as the changes were too numerous to deal with by correction. This was carried out on plots of the old traverse data of 1871-77, the old station marks being found with very few exceptions. The total area of survey and map correction was 789 square miles, and that for which records were written 754 square miles. The difference is due to the large number of incompetent *patwáris* and the difficulty experienced in procuring local substitutes; it will not delay the sanctioned programme of operations, which prescribes the 1st of November as the date for commencement of attestation. On an average 3·84 linear miles of check survey per square mile have been run through the work, and 27 per cent of the *khasra* entries checked on the ground. Of 207 *patwáris*, 146 proved competent, 28 were allowed to provide their heirs to do their work, and substitutes had to be provided for 33. The cost-rates are Rs 30·4 per square mile for cadastral correction and re-survey, and Rs 10·6 per square mile for record-writing. The corrected maps have been traced for reproduction by the Vandyke process and will be printed within the next few months. Operations will close in this district in November 1907.

195. *Camp No. 4.*—In Hamírpur field work commenced in October 1903, and was similar to that carried out in Bánáda. The

Personnel.

Mr. P. C. H. Smart, Extra Assistant Superintendent, 4th grade, in charge.

" C. S. Littlewood, Sub-Assistant Superintendent, 1st grade.
17 Inspectors, 163 *patwáris*, etc.

survey and map correction of *parganas* Hamírpur, Sumerpur, and Maudha, 613 square miles, were completed during

the year, and the annual *patwári* papers written for the same area. The amount of re-survey required was about the same as in Bánáda, but the cost-rates are rather higher, being Rs 40·5 for cadastral work, and Rs 13·5 for record-writing, which is accounted for by the obliteration of almost all the old traverse station marks. This necessitated the temporary fixing of a large number of auxiliary stations from the trijunction marks, which fortunately were generally found well marked. The maps were tested by an average of 4·3 linear miles of check survey, and 24 per cent of the *khasra* entries were checked on the spot. Of 163 *patwáris*, 136 proved competent, 16 were allowed to provide their heirs to do the survey, and substitutes had to be provided for 11. Operations will close in this district in November 1906.

196. *Drawing Office.*—During the season the drawing office has submitted

Personnel.

Mr. J. M. Kennedy, Extra Assistant Superintendent, 3rd grade, in charge.

1 Sub-surveyor, 11 to 24 draftsmen, typers, etc.

for publication, standard sheets Nos. 6, 7, 8, 82, 83, 84, 98, 99, 100, 113, 114, and 192, and the district maps of Bareilly, Sháhjahánpur, and Lalitpur. The standard sheets were drawn on the 2-inch scale for reduction to half, from modern material

Arrears Section.

Mr. W. C. Price, late Extra Deputy Superintendent (re-employed).

11 Draftsmen.

with the exception of sheets 7 and 8 of which the old fair maps were corrected and revised. The remaining sheets of Meerut, 17, 18, 19, 30, 31, and 32, will be similarly revised and submitted next year. Sheet 89 (Farrukhabad) is in hand, and the standard mapping of Kheri, Bahraich, and Gonda will be proceeded with. Printed copies of the standard sheets of Hamírpur and Bánáda will be corrected in the cadastral offices of those districts, and the original sheets will be afterwards corrected in the drawing office; those sheets which include portions of Allahabad, Fatehpur and Cawnpore, being considered as most urgent.

The one sub-surveyor attached to the office surveyed 114 square miles of the Jumna and Rámganga beds in sheets 7, 8, 68, 69, 84, and 85, during the season, and in conjunction with a sub-surveyor temporarily attached from No. 14 Party, revised the area including the town and environs of Agra in sheet 25, after the latter had revised the 4-inch military map of Lucknow.

An arrears section of the office was instituted in September 1904, to bring up the mapping of districts in arrears, and was placed in charge of Mr. W. C. Price, a retired Provincial officer.

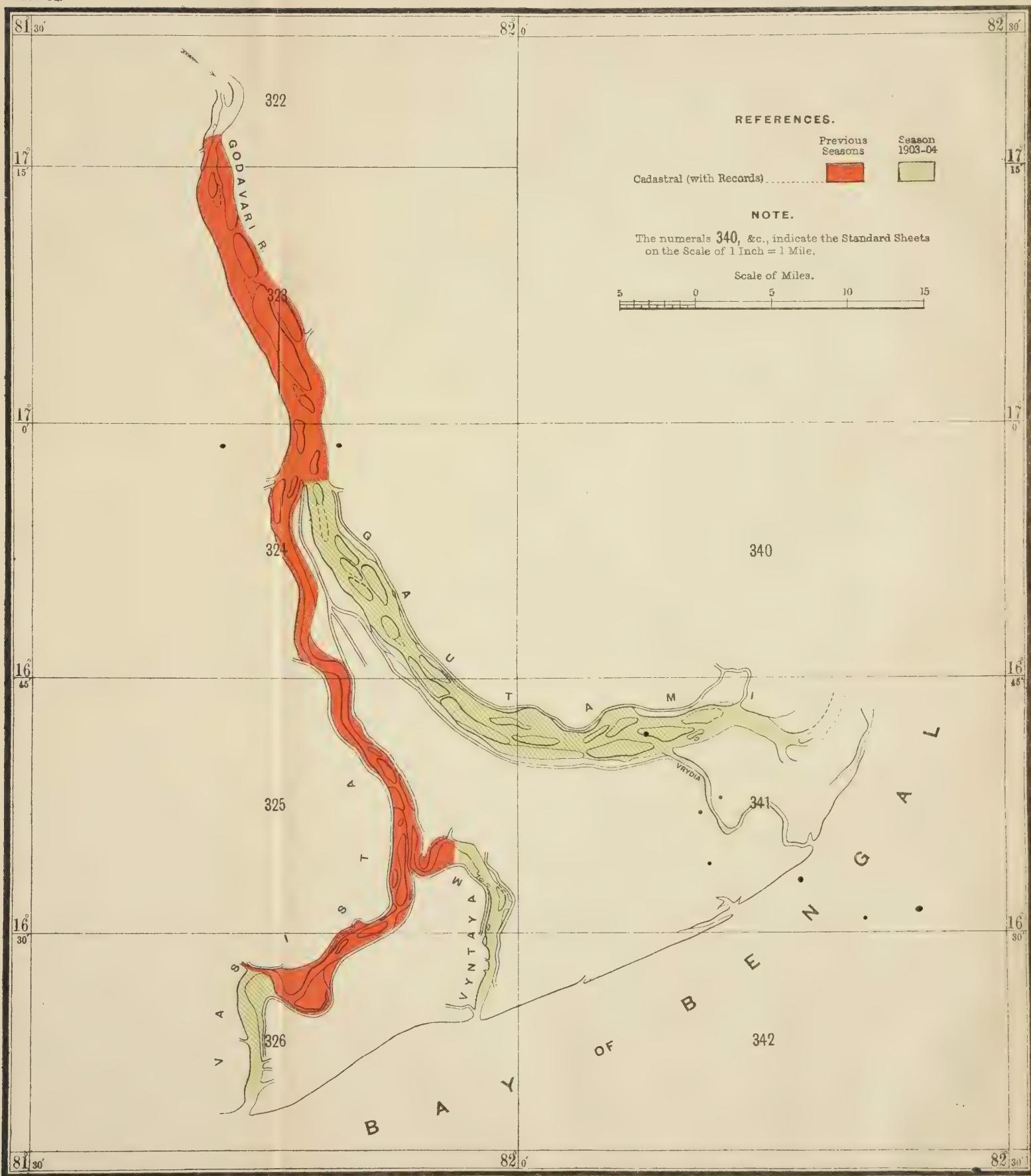
197. The programme for next season consists of the topographical survey of the course of the Gogra in sheets 29, 30, 31, and 32, the traverse and

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

MADRAS.
INDEX TO THE GODAVARI CADASTRAL SURVEY.

1903-04.

DETACHMENT.



cadastral survey of 315 square miles in Moradabad, the correction of the cadastral maps of 2,000 square miles in Moradabad, Hamírpur, and Báná, town survey in Cawnpore and Moradabad, and 1,146 linear miles of road survey in Oudh.

198. The Surveyor General and Deputy Surveyor General inspected the drawing office and traverse camp at Naini Tal in August. The Superintendent of Provincial Surveys inspected the office of each camp in the field and during recess, inspected and checked the cadastral work in progress in Moradabad, Hamírpur and Báná, and the topography along the Jumna and Rámganga and examined and reported on the cadastral maps of the Ballia riverain areas.

GODAVARI DETACHMENT.

199. The origin of this survey and the nature of the operations were described in last season's annual report. The survey was commenced in 1901-02

Personnel.
Mr. S. F. Norman, Sub-Assistant Superintendent, 1st grade.
5 Sub-surveyors, 2 computers, 1 draftsman, 54 ámins.

when the whole area was

triangulated. This season's field work commenced on the 10th November 1903, the early part of the season being devoted to traversing only as none had been done in advance the previous season, owing to the late date on which definite orders were received to take up the survey. Detail survey commenced at the end of January and was completed by the end of April, but the writing of the registers or *adangals* continued until the 10th July, when the detachment moved into recess quarters at Rajahmundry. The outturn for the season was 135 square miles, of which both traversing, detail survey on the scale of 16 inches to the mile, and record-writing were done. Again this season there was no demarcation although the necessary notices were issued; only one dispute was registered however but this is probably due to the lack of interest evinced in the survey by the cultivators who would not attend even when the registers were being written up. The assistance of the Collector had to be invoked to compel their attendance as well as that of the village *kernáms* under whose superintendence the records were written and whose attendance was very irregular. The records were written by 8 ámins of the Madras Revenue Survey while 12 who were entertained locally were employed on revising the maps and registers of the previous season.

200. Numerous cocoanut and plantain groves added considerably to the amount of traversing required, necessitating a very large number of sub-traverses. The number of linear miles traversed was 295. The traverse stations were marked with wooden pegs as the whole area surveyed is subject to inundation, and permanent marks fixed by triangulation had been erected along the high banks beyond the reach of floods and the traversing was connected with these marks.

201. The detail survey was checked by 139 linear miles of test lines run by Mr. Norman including independent *partáls*, an average of a little over one linear mile to every square mile surveyed. In addition to this, 188 linear miles of test lines were run by native inspectors, who also checked 33 per cent. of the entries in the registers. The computations, mapping and area statements were all completed by the 15th November 1904, when the detachment was broken up.

202. Traces of the 16-inch maps were sent to the Surveyor General's office for reproduction, and orders are awaited as to the number of copies required. The original maps with copies of the registers were sent to the Collector for exhibition in his office for a period of 90 days, after which it is understood, they have to receive the approval of the Government of Madras before copies are printed. The original registers were sent to the office of the Superintending Engineer at Ootacamund.

203. The total cost of this survey from the commencement is R54,961, and the total area surveyed on the 16-inch scale, 265 square miles. These figures are subject to slight modification as the later accounts have not yet been audited. The cost is considerably higher than it would have been had timely orders been received to take it up, as it would then have been completed in one season. In any case the cost must necessarily have been high, as most of the establishment had to be imported from upper India. A sum of R2,646

had to be paid as compensation for trees that were cut down to enable the triangulation to be carried out.

204. The Deputy Surveyor General, Colonel Hobday, inspected the detachment in the field during May, and again during August at recess quarters.

ASSAM DETACHMENT.

205. The detachment continued traverse work and also carried out some boundary demarcation

Personnel.

Mr. T. Shaw, Extra Assistant Superintendent, 1st grade, Superintendent, Provincial Surveys, Assam, in charge.

Mr. G. J. S. Rae, Extra Assistant Superintendent, 6th grade, from 1st November 1903 to 24th June 1904.

Mr. C. A. O'Donel, Sub-Assistant Superintendent, 1st grade.
20 Sub-surveyors, computers, draftsmen, etc.

for the local administration. The actual areas traversed are shown in the following statement :—

DISTRICT.	Number of villages.	Number of tea grants.	Area in square miles.	REMARKS.
Darrang . . . . .	...	21	15	
Nowgong . . . . .	...	25	16	
Sibságar . . . . .	...	4	4	
Lakhimpur . . . . .	...	57	56	
Cachar	5	...	4	For cadastral survey.
TOTAL	5	107	95	

206. As in former seasons the traverses have been connected with those of the late No. 6 Party, and can be plotted in their correct positions on the standard maps. In the skeleton boundary surveys of the tea-grants in the Assam valley, 703 permanent marks for future topographical surveys have been fixed and 107 tea-grants have been located. The very poor outturn may be attributed partly to the scattered nature of the operations and partly to want of supervision in the field. Mr. Shaw was able to visit the sub-surveyors in Lakhimpur district only once and that late in the season, while Mr. O'Donel was employed throughout the season on boundary demarcation remote from the districts in which traversing was in progress.

207. The cost-rates are exceptionally high owing to the small outturn of work. In the Cachar and Sibságar districts where the areas were less than 4 square miles, the cost-rates were R283 and R253 a square mile, respectively. The following tabular statement gives the cost-rates per square mile by districts :—

	R
Darrang	100 Tea-grants.
Nowgong	139 "
Sibságar	253 "
Lakhimpur	113 "
Cachar	283 Villages.

208. No topographical surveys were undertaken in the Province during the year. The preparation of standard maps was continued under Mr. Rae during Mr. Shaw's absence on tour, and 17 standard sheets on the 1-inch scale were submitted for publication during the season. The standard mapping of areas surveyed by No. 6 Party in Cachar and Sylhet districts has been completed and the mapping of *Serail pargana*, Tippera State, has been taken in hand to complete the maps up to graticule limits. In the Assam valley the areas surveyed by No. 6 Party have been completely mapped, and the work of making additions from surveys made since the formation of the Assam detachment is now in progress. The preparation of district maps on the scale of 8 miles to the inch for the Provincial Gazetteer and the maps of Goálpára and Kámprúp are well advanced. Information regarding boundaries of *mauzas* and communications in all districts is also being got together to meet the requirements of the Gazetteer Superintendent. When the gazetteer maps are finished it may be possible to reduce the strength of the drawing establishment.

UNIVERSITY OF ILLINOIS

2

2

2

2

2

2

2

2

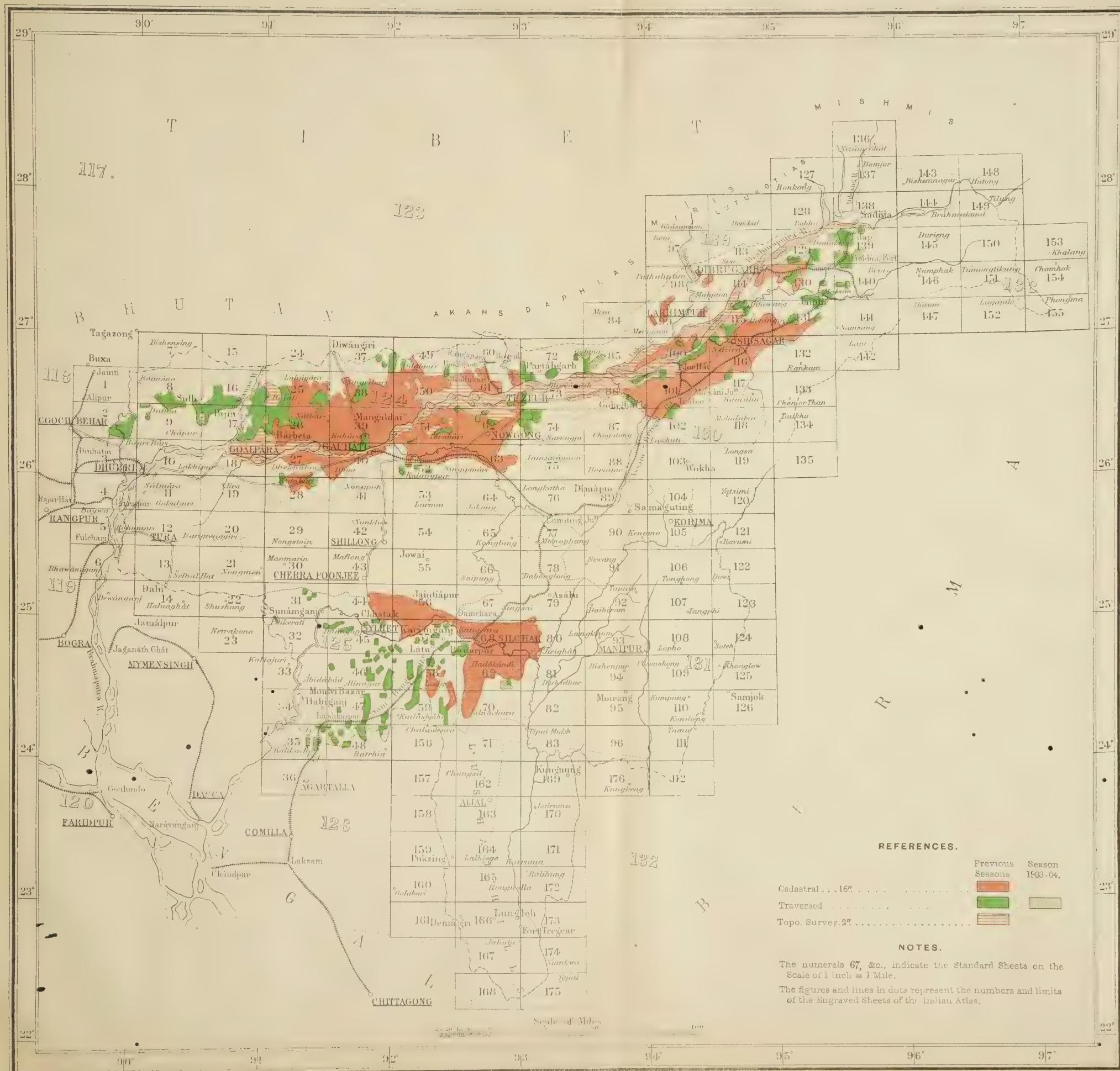
N

A Y C A M.

INDEX TO RECENT CADASTRAL, TRAVERSE, & TOPOGL. SURVEYS IN THE BRAHMAPUTRA & SURMA VALLEYS.

1903-04.

ASSAM DETACHMENT.



REFERENCES

	Previous Seasons	Season 1903-04.
Cadastral . . . 16"		
Traversed		
Topo Survey 2"		

NOTES

The numerals **67**, &c., indicate the Standard Sheets on the Scale of 1 Inch = 1 Mile.

The figures and lines in dots represent the numbers and limits
of the Engraved Sheets of the Indian Atlas.

No. 802 S. I.—Jan. 05.—650.

Litho., S. I. O., Calcutta

Reg. No. 659-S. 05.

209. A class for training local officers in practical field surveying was held at Palásbári in the Kámbrúp district during February 1904. Mr. Shaw instructed one Assistant Commissioner, three Extra Assistant Commissioners and four Sub-Deputy Collectors. He also conducted an examination for first class certificates at the survey schools of Dibrugarh, Jorhát, and Gauháti and examined two pleaders in surveying at Sylhet. This examination was held to test the qualifications of pleaders for appointments as commissioners in civil suits as required by the High Court.

210. The programme for next field season is:—

DISTRICT.	Traversing for cadastral survey by local agency.	Skeleton traversing of tea- grants.	
		Sq. miles.	Sq. miles.
Kámbrúp	15	16	
Nowgong . . . . .	...	3	
Sibságár . . . . .	...	5	
Lakhimpur . . . . .	...	108	
	15	132	

TRIGONOMETRICAL SURVEYS.

INDIA TRIANGULATION.

NO. 24 PARTY.

211. The programme of work

Personnel.

Captain H. Wood, R.E., Assistant Superintendent, 1st grade, in charge up to 2nd September 1904.

Captain H. H. Turner, R.E., Deputy Superintendent, 2nd grade, in charge from 3rd September 1904.

Mr. D. J. Hunter, Sub-Assistant Superintendent, 1st grade.

Mr. C. D. Simons, Sub-Assistant Superintendent, 2nd grade.

3 Recorders, 1 writer.

The officer in charge was employed during the remainder of the cold weather in observing geodetic azimuths at some of the longitude stations of India and Burma. The Provincial officers were employed during the entire season in building stations for the Great Salween series, and so good was the progress made that stations have been built as far south as latitude $20^{\circ}30'$. At Quetta, in addition to observing an azimuth, Captain Wood observed an astronomical latitude, and in conjunction with Captain Pirrie at Nushki, a telegraphic longitude. Messrs. Troughton and Simms' 12-inch Theodolite No. II was used for the azimuth and latitude work. A synopsis of the results is given below:—

Azimuth Observations.

STATION.	Latitude N.	Longitude E.	Value in seconds of difference in azimuth (Astronomic — Geodetic).	Difference in seconds of value obtained from stars of eastern and western elongations E.—W.
Jalpaiguri S	26° 31' 15"	88° 46' 41"	+5	+0.03
Orejhár H. S.	26° 46' 56"	82° 14' 35"	-4.06	-0.66
Kyaunggyi S.	18° 49' 21"	95° 15' 24"	-7.80	-0.55
Bolarum P. W. D. Office S.	17° 30' 11"	78° 33' 38"	-1.1	+0.34
Deesa Tele. Office S. . .	24° 15' 30"	72° 13' 33"	-4.59	-0.62
Quetta Tele. Office S. . .	30° 11' 57"	67° 2' 59"	-4.86	+1.73

Latitude.

STATION.	Geodetic latitude=C.	Astronomic latitude=O.	O-C.	Probable error.
Quetta Tele. Office S. .	° ' " 30 11 57'37	° ' " 30 11 55'82	" -1'55	±0'089

Longitude.

The difference in longitude between Quetta Telegraph Office S. and Nushki longitude S. is $0^{\circ} 59' 53''$.

SCIENTIFIC OPERATIONS (GEODETIC).

ASTRONOMICAL LATITUDES.

No. 22 PARTY.

212. This party was employed on triangulation and latitude operations

Personnel.

Major S. G. Burrard, R.E., Superintendent, in charge from 8th March 1904.

Captain H. M. Cowie, R.E., Officiating Deputy Superintendent, 2nd grade, in charge up to 7th March 1904.

Babu Hanuman Prasad, Sub-Assistant Superintendent, 1st grade.
1 Computer.

in the Himalayas, north of Mussooree. Questions of geodetic interest concerning the mass and attraction of the Himalaya mountains have been raised of recent years, and the programmes of the astronomical parties have been designed to obtain evidence on definite points. In 1901-02 and 1902-03, both astronomical parties were

engaged in carrying latitude operations across the Ganges valley from the Vindhya to the Himalayas, with the object of testing, as was explained on page 9 of the General Report of the Survey of India for 1902-03, whether a longitudinal region existed, running parallel to the Himalayas from Calcutta to Jodhpur, throughout which the deflection of gravity was southerly. The observations taken in those years showed that southerly deflections of gravity such as had been previously found to exist in the Ganges valley on the meridians of $77\frac{1}{2}$ and 80, were prevalent, also on the meridians of $78\frac{1}{2}$ and 88.

213. In April 1903 Captain Cowie was directed to observe for latitude at the Himalayan station of Birond to test whether the large deflections of gravity, which had been discovered at Dehra Dún and Darjeeling, would be met with also in Kumaun: the opinion had been expressed in Europe that these large deflections would be found to be local and exceptional, but as was pointed out on page 60 of the General Report for 1902-03, the Birond result has proved that large deflections in sub-Himalayan regions are the rule and not the exception.

214. In October 1903, Captain Cowie was directed to extend the Great Arc of India northwards across the Mussooree hills to the snowy range, and to observe for latitude at stations in the inner Himalayas. A high geodetic authority had expressed the opinion that the large deflections of gravity at Dehra Dún; Birond and Darjeeling were due not to the Himalayan mass, as had been assumed in the Survey of India Professional Paper No. 5 of 1901, but to the peculiar geological formation of the lower and outer range, and that they would be found to disappear when the first Himalayan range was crossed, and that large southerly deflections would be met with in the inner Himalayas. Captain Cowie added one tetragon and two triangles to the Great Arc of India, and extended it from latitude $30^{\circ} 29'$ to latitude $31^{\circ} 1'$ over a distance of about 35 miles. His triangulation emanated from Everest's side Banog-Sirkanda, and he observed horizontal angles at the stations of Kedárkánta, Lambáthásh, Bájamára,

Banog, Nagtibba and Bâhak. Captain Cowie also observed for latitude at four of the Himalayan stations and his results are included in the following table :—

Series.	Station.	Height above mean sea-level.	Longitude.	Geodetic Latitude = O.	Astronomical Latitude = C.	Probable Error.	Deflection of plumb lines = O-C.
Great Arc Section 24° to 30°.	Dehra Dún, East } end of Base.	1,958	78 1 30 17 7'35	30 16 37'29	±0.082	-30°06	
	Dehra Dún . . .	2,289	78 6 30 19 57'07	30 19 19'56	±0.18	-37°51	
	Râjpur . . .	2,997	78 8 30 23 56'67	30 23 9'33	±0.108	-47°34	
	Mussooree . . .	6,937	78 7 30 27 40'55	30 27 4'02	±0.104	-36°53	
	Bâhak, H.S. . .	9,715	78 16 30 45 5'28	30 44 37'54	±0.102	-27°74	
N. W. Himalaya Series.	Bájámára, H.S. . .	9,681	77 56 30 45 56'07	30 45 27'92	±0.077	-28°15	
	Lambáthâsh, H.S.	10,474	77 57 31 1 7'65	31 0 35'20	±0.099	-22°45	
	Kedárkânta, H.S.	12,509	78 13 31 1 22'09	31 0 51'21	±0.073	-30°88	

215. It will be seen from this table that large northerly deflections continue to prevail in the heart of the Himalayas, and that no southerly deflections have been met with. It is unsafe perhaps to generalise from the observations of one locality, but Captain Cowie's results seem to indicate that a great disturbance of gravity exists over a large area—a disturbance which it is difficult to reconcile with Archdeacon Pratt's theory of Himalayan compensation.

216. The field-work of the party was closed prematurely as Captain Cowie was ordered to join the Tibet Frontier Mission.

217. The party was inspected by the Superintendent, Trigonometrical Surveys, in June 1904.

PENDULUMS.

NO. 23 PARTY.

218. Up to December 14th, 1903, No. 23 Party was engaged, in combination with No. 22, on latitude operations,

Personnel.

Major G. P. Lenox-Conyngham, R. E., Superintendent, 2nd grade, in charge.

Babu Hanuman Prasad, Sub-Assistant Superintendent, 1st grade.

1 Sub-surveyor, 1 writer and computer.

both parties being in Lieutenant Cowie's charge. On Major Lenox-Conyngham's return from leave he took charge of the party and the work undertaken was the revival of the pendulum observations

which had been brought to a close in 1870.

219. The former determinations of the force of gravity were carried out at the instance of the Royal Society and with their pendulums. In 1901, it was decided that pendulum observations should be revived in India and an apparatus of Colonel Von Sterneck's pattern, including four half-seconds pendulums, was purchased. Professor Helmert, Director of the Central Bureau of the International Geodetic Association and of the Prussian Geodetic Institute, kindly undertook to procure and test the equipment and also to have the constants of the corrections determined. In October 1902, Major Burrard and Captain Lenox-Conyngham, who were on leave in England, went to Potsdam to study the use of the pendulums at the Prussian Geodetic Institute under Professor Helmert.

220. The next step was to select a base station, where the absolute value of gravity was known, and there to standardise the pendulums. Kew was chosen, as it had been the base station of the former series of observations, and at the suggestion of the Astronomer Royal and the Director of the National Physical Laboratory, a set of observations was made at Greenwich also.

221. The results of the observations at Kew and Greenwich are as follows :—

TABLE I.

No. of Pendulum.	137	138	139	140	Mean.
	Sec.	Sec.	Sec.	Sec.	Sec.
Time of vibration at Kew	0.5067070	0.5069490	0.5066104	0.5065339	0.5067001
Time of vibration at Greenwich	0.5067104	0.5069525	0.5066140	0.5065374	0.5067036
Difference	0.0000034	0.0000035	0.0000036	0.0000035	0.0000035

A difference of 0.0000035 sec. in the time of a vibration corresponds to a difference in the intensity of gravity of 0.014 of a dyne, so that taking the value of g at Kew to be

$$\text{Cm.} \\ 981.200$$

that at Greenwich becomes

$$\text{Cm.} \\ 981.186$$

The probable error of this result may be estimated to be ± 0.002 . Cm.

The difference of g at Kew and Greenwich has been repeatedly determined, with the following results :—

		Cm.
Sabine	1831	By determination of length of seconds
Heaviside	1873	pendulum 0.069
Herschel	1881	Kater's invariable pendulums Nos. 4 and 6 0.038
Constable	1888	Kater's invariable pendulums Nos. 4, 6 and 11 0.028
Hollis	"	Putnam 1900 Three half-seconds pendulums 0.012
Burrard	1903	Constable Lenox-Conyngham 1903 Four half-seconds pendulums 0.014

222. The theoretical difference between the values of g at Kew and Greenwich according to the well known formulæ.—

$$Y = 978.000 \left(1 + 0.005310 \sin^2 \Phi \right) \left(1 - \frac{s}{R} \right) \text{ is } 0.012$$

The agreement of the more recently observed results with the theoretical value tends to inspire confidence in the methods of observing which have now been arrived at, for it was difficult to believe that the value of g could be subject to marked variation in localities where no abrupt geological changes occur.

223. Immediately after the close of the work at Kew and Greenwich, Major Lenox-Conyngham embarked for India carrying the pendulums with him. The first work to be undertaken in India consisted (1) of a thorough standardisation at Dehra Dün, which is to be the base station for all India; (2) of a connection with several stations at which the old pendulums had been swung by Captains Basevi and Heaviside; and (3) of a commencement of the observations at stations situated in high mountains, which will form not the least interesting branch of the India pendulum operations.

224. In the following table the stations visited during the season 1903-04 are given, together with an abstract of the results :—

TABLE II.

Station.	Latitude.	Height above mean sea-level, h .	Observed g .	$g \cdot \frac{2h}{r} = A$	$g \cdot \frac{h}{4} = B$	Orographical corr. = O.	$+A+B+O = g''$	Theoretical value at sea-level y .	$g'' - Y$
Dehra Dün	$30^{\circ}19'29''$	2,241	979.063	+.210	-.079	+.007	+.007	979.324	-.123
Madras	$13^{\circ}4'8''$	23	978.281	+.002	-.001	0	0	978.266	+.916
Kolába	$18^{\circ}53'47''$	32	978.632	+.003	-.001	0	0	978.545	+.089
Mussooree, Dunseverick	$30^{\circ}27'31''$	7,131	978.778	+.668	-.251	...	...	979.334	...
Mussooree, Camel's Back	$30^{\circ}27'41''$	6,924	978.795	+.649	-.243	+.027	979.228	979.335	-.107
Dehra Dün	$30^{\circ}19'29''$	2,241	979.066	+.210	-.079	+.007	979.204	979.324	-.120

225. Calcutta was also visited, but Major Lenox-Conyngham found that it was impossible to take observations there, as the vibrations of the ground were so great as to set up in a few minutes sensible oscillations in the small pendulums of this apparatus. Captain Basevi's pendulums were four times as long as Major Lenox-Conyngham's, and it is probable that the earth tremors were of too short period to affect them, for the behaviour of clocks with seconds pendulums in Calcutta seems to be satisfactory.

226. The quantity $g_0 - g$, in Table II indicates the difference between the observed attraction of the visible mass and that which the latter would exert if it possessed a density equal to half the mean density of the earth.

The deficiency in g at Dehra Dün is such as would be caused by the subtraction of a layer 3,440 feet thick, and of a density equal to half the mean density of the earth, so that in estimating deflections of the plumb line, Dehra Dün should be regarded as being about 1,200 feet below sea-level.

TIDAL AND LEVELLING OPERATIONS.

No. 25 PARTY.

TIDAL OPERATIONS.

227. Observations were taken at the following tidal stations during the survey year :—

STATIONS. (Those shown in italics are permanent).		Automatic or Personal observations.	Date of com- mencement of observations.	Date of closing of observations.	Number of years of observa- tions.	REMARKS.
1	Suez	Automatic .	1897	1903	7	Closed on 18th February 1904.
2	Aden	"	1879	Still working	24	
3	Karachi	"	1881	"	23	
4	Okha Point	"	{ Restarted 1874. 1904.	{ 1875	1	Opened on 22nd Janu- ary 1904.
5	Port Albert Victor (Káthiá- wádar.)	"	1900	1903	4	Closed on 21st April 1904.
6	Bombay (Apollo Bandar)	"	1878	Still working	26	
7	Bombay (Prince's Dock)	"	1888	"	16	Property of Port Trust.
8	Madras	"	{ 1880 Restarted 1895.	{ 1890 Still working.	10 } 19	
9	Kidderpore	"	1881	"	9 } 23	
10	Bassein (Burma)	"	1902	1903	2	Closed on 1st January 1904.
11	Rangoon	"	1880	Still working	24	
12	Port Blair	"	1880	"	24	

228. The nine tidal observatories now working were inspected during the
" Personnel.

Captain H. H. Turner, R. E., Deputy Superintendent, 2nd grade, in charge from 1st October 1903 to 28th September 1904.

Mr. J. P. Barker, Extra Assistant Superintendent, 4th grade, in charge from 29th to 30th September 1904.

Mr. H. G. Shaw, Extra Assistant Superintendent, 5th grade.

Mr. E. H. Corridon, Sub-Assistant Superintendent, 1st grade.

Munshi Syed Zille Hasnain, Sub-Assistant Superintendent, 2nd grade.

26 Surveyors and computers, etc.

year; in addition to these Suez, Port Albert Victor and Bassein (Burma) were visited and finally closed. The registrations at all the observatories have been satisfactory.

229. Tidal observations have again been started at Okha Point in the gulf of Cutch after a lapse of 30 years, and the question as to whether any secular change has taken place round the gulf, will now be finally settled.

230. The two following tables show the annual and decadal percentages of the predicted time and height errors of high and low water at open coast and riverain stations.

Percentages of errors in predicted times and heights at open coast stations from automatic registrations.

YEAR.	Number of Stations,	IN TIME.		IN HEIGHT.			
		Within 15 minutes of actuals.		Within 8 inches of actuals.		Within $\frac{1}{10}$ of mean range at springs.	
		H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
1894	10	65	62	95	92	97	95
1895	9	68	65	98	97	94	94
1896	9	71	70	97	97	97	93
1897	8	71	75	96	97	97	97
1898	9	74	70	96	96	95	95
1899	9	74	66	95	95	93	92
1900	11	66	60	93	88	93	89
1901	11	71	60	93	91	93	91
1902	9	76	67	94	95	96	96
1903	8	80	77	92	93	94	94
Average of 10 years.	9	72	67	95	94	95	94

Percentages of errors in predicted times and heights at riverain stations from automatic registrations.

YEAR.	Number of stations,	IN TIME.		IN HEIGHT.			
		Within 15 minutes of actuals.		Within 8 inches of actuals.		Within $\frac{1}{10}$ of mean range at springs.	
		H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
1894	2	56	55	66	42	88	80
1895	2	59	55	74	47	94	84
1896	2	56	55	63	42	87	74
1897	2	59	61	75	57	96	91
1898	2	53	59	71	61	90	91
1899	2	55	59	76	65	95	94
1900	2	59	62	70	57	89	87
1901	2	63	65	70	59	90	92
1902	2	63	54	76	53	96	90
1903	2	55	61	70	60	88	87
Average of 10 years.	2	58	59	71	54	91	87

231. The tide predicting machine has been moved to the National Physical Laboratory at Teddington and Dr. Glazebrook now supervises the tide predictions.

232. A reconnaissance of the coasts of the Malay peninsula about Kedah, on the west and Singora on the east, will be made next field season with the object of finding suitable sites for tidal observatories.

SPIRIT LEVELLING OPERATIONS.

233. The levelling detachment was employed in Burma and continued the line of levels from Shwebo to Wuntho on the line Sagaing to Myitkyina, where the work was closed and the detachment was then employed on the revision work between Mandalay towards Rangoon, and revised the old work up to Pyinmana.

The detachment then proceeded to Dehra Dún and levelled from Dehra Dún to Mussooree, and closed on the Great Trigonometrical survey station on the Camel's Back, 301·7 miles of double levelling were completed ; this includes the revision work and the line from Dehra Dún to Mussooree.

The detachment left Dehra Dún on the 17th October 1903, and returned to recess quarters on the 30th May 1904.

234. During next field season the following work in connection with levelling operations will be taken up:—

- (1) Levelling in Sind from Sujáwal to the Baháwalpur boundary.
- (2) The reconnaissance of the road between Kédah and Singora in the Malay peninsula, in order to ascertain whether it is suited for precise levelling.
- (3) The erection of standard bench-marks in the principal towns in the United Provinces of Agra and Oudh.

MAGNETIC.

NO. 26 PARTY.

235. Five field detachments were employed in extending the work during

Personnel.

Captain H. A. D. Fraser, R.E., Deputy Superintendent, 1st grade, in charge up to 27th May 1904, and from 4th July to 31st August 1904.

Lieutenant R. H. Thomas, R.E., Officiating Assistant Superintendent, 1st grade, in charge from 1st September 1904.

Mr. H. P. D. Morton, Sub-Assistant Superintendent, 1st grade.

Babu R. P. Ray, " " 2nd "

Mr. A. M. Talati, " " 2nd "

" E. A. Meyer, " " 2nd "

Babu N. R. Mazumdar, " " 2nd "

3 Magnetic observers, 1 surveyor, 2 computers, 6 recorders, 1 writer.

the working season, in addition to which two Imperial officers divided between them the observations at repeat stations, the inspection of field detachments, and the comparison of instruments at the fixed observatories.

236. The total of new work completed during the season amounted to 232 stations, in addition to which 24 old stations were revisited. The total number of stations so far occupied is 600 in three seasons' work, so that the fundamental survey is now more than half completed.

237. Lieutenant Thomas was fully trained in taking magnetic observations and the adjustment of magnetographs.

238. The results of the season's work are tabulated and published in the appendix together with an index chart showing the distribution of all stations of observation occupied up to date. The observatory at Dehra Dún remained in charge of observer Shri Dhar throughout the year, and there was no serious break in the records till September when, after continuous heavy rain, the underground room was flooded to a maximum depth of 22 inches and work was stopped for a period of 17 days altogether. It is hoped that the measures since taken will prevent a recurrence of the trouble, but in the light of past experience it is impossible to be quite certain. It is satisfactory to note that the instruments themselves have in no way suffered from the damp and are now giving as good results as formerly.

Numerous special observations of all kinds were made during the year at the Dehra Dún observatory.

239. The work at Kodaikánal observatory has not been completely satisfactory during the past year, as there have been several changes of observers owing to resignations, sickness and other causes, added to which the instruments themselves have given trouble. The observatory itself has not suffered from leaks, or excessive dampness, so that the measures taken last year to overcome these defects seem to have answered their purpose. In spite of this, however, the declination magnetograph again showed signs of interference in April 1904, and in the following month, Lieutenant Thomas opened up the instrument to discover the cause of it. He found nothing which could account for the lack of freedom exhibited by the magnet, but fitted new mirrors and a new suspension, and since then the instrument has behaved normally.

Regulations have been drawn up and adopted which define the relative responsibilities of the Director of the Solar Physics Observatory, and of the officer in charge of No. 26 Party (Magnetic) with regard to the magnetic observatory, and thanks are due to the former for his cordial assistance in all matters connected with the magnetic work.

240. The Barrackpore observatory has given satisfactory results throughout the year, and has been under the charge of observer K. N. Mukerji the whole time, except during his absence on sick leave from 25th January to

24th March 1904. The instruments have behaved well and the buildings have proved satisfactory except that the annual range of temperature in the magnetograph room is at present undesirably large. It has now been decided to ask for sanction to enclose the outer verandah entirely with wood and when this is done, the annual range should be considerably reduced.

241. In November 1903, the officer in charge inspected the buildings at Kokine near Rangoon, and made the necessary arrangements with the Public Works Department for the minor alterations which seemed desirable. A few months later and only a short time before the magnetographs arrived from England, intimation was received that it would be necessary to carry the alignment of the large cast iron main of the new Hlawga water-supply within a few feet of the existing magnetograph house. Enquiries were made and it was found that not only would it be impossible to alter the alignment to a safe distance at a reasonable cost, but that there was a project for laying a local railway line in the immediate vicinity which would probably be commenced at an early date. The only course open was to shift the site of the observatory to another locality and to erect the new buildings as speedily as possible. Towards the end of April 1904, the officer in charge proceeded to Burma and after selecting a suitable site at Toungoo, went to Maymyo where the preliminary financial arrangements were settled with the Chief Engineer to the Burma Government. The plans and specifications for the buildings were then prepared in consultation with Mr. Moran, the Executive Engineer at Toungoo, and the whole case sent to the Government of India for disposal. A few weeks later sanction to commence work was given, and thanks to the energy displayed by the Executive Engineer, the buildings are now ready to receive the instruments. The new buildings are entirely above ground and similar to those erected at Barrackpore where the conditions are somewhat similar. The instruments have arrived from England and will be in working order before the end of 1904.

242. The recess work commenced in May and owing to the accumulation of records at the base stations, proved exceptionally heavy. In order to cope with it, the Superintendent of Trigonometrical Surveys temporarily increased the strength of the party, and also added two computers to its regular establishment. The effect of these timely measures has been to bring practically the whole of the work up to date, and by making available the tabulated results from the base stations, to permit of an investigation of the reduction formulæ. This work has now been commenced by Mr. J. Eccles, M.A.

243. During the ensuing working season field work will be carried on by four detachments, partly along railways but chiefly in those parts of Central India and of the Madras and Bombay Presidencies which can only be reached by road.

The following season, 1905-06, will, it is hoped, witness the completion of the whole of India, west of the meridian of Calcutta, whilst the season 1906-07, should complete the field work appertaining to the fundamental survey.

TABULAR STATEMENTS.

Summary of the Outturn of Work of the

SCALE OF SURVEY.	Number of Party.	Locale of Operations.	TRIANGULATION.												SPIRIT-LEVELLING OPERATIONS.					
			Instrument used. Diameter in inches.			Area in square miles.			Square miles to each point trigonometrically fixed.			Square miles to each height.			1ST CLASS.		SECONDARY.		TERTIARY.	
		Brought forward .				1911														
17		Bombay Forests .	...	6 & 7	677	1'9													
18	{	Multán and Muzaffargarh .	45	...	...	1911													
		Muzaffargarh and D. G. Khan.	...	...	...	1'9													
		Madras Forests—Godávari, Trichinopoly and Chingleput.	...	...	1,220	1'8													
19	{	Madras Forests—Kistna and Kurnool.	...	...	289	1'8													
		Madras Forests—South Canara.	...	...	428	1'8													
		Madras Forests—Coimbatore.	50	...	...	...											
20		Burma Forests { Upper Chindwin, Lower Chindwin, Thayetmyo.	...	5 & 6	610	27'7	27'7	...	...	...	...	...	...	...	296	16	1,388	0.6	
		TOTAL .	...	...	5,135	...	...	...	...	...	...	...	...	...	...	...	...	...	Miles levelled over.
2	1	Central Provinces—Saugor and Damoh.	55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8		United Provinces of Agra and Oudh—Meerut, Bulandshahr, Bareily, Budaun and Sháhjahánpur	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	{	Sind .	...	6 & 7	4,222	14	14	...	...	...	...	...	...	...	66	6.6	0.24	212	0.43
		United Provinces of Agra and Oudh—Allahabad.	...	6	650	6	6	...	...	...	...	...	...	...	12	15	0.33	88	1.1
14	{	United Provinces of Agra and Oudh—Fatehpur and Cawnpore.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	{	North-West Frontier Multán, Amritsar and Baháwalpur State.	60	6	1,460	24'7	24'7	...	...	...	...	...	...	...	59	10	0.25	574	0.25
18		Ferozepore .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		TOTAL .	...	...	6,332	...	...	...	...	...	...	...	...	...	...	...	...	...
I	3	Lower Burma .	...	6	4,836	5	5	...	...	...	...	...	...	...	109	9.6	0.23	945	0.6
9		Darjeeling (Kalimpong) .	...	7	20	1'1	1'1	...	...	...	...	...	...	...	8	15	0.3	8	0.3
10		Upper Burma .	65	5 & 6	1,725	11	11	...	...	...	...	...	...	...	46	6.9	0.16	93	0.3
11		Upper Burma	6	2,714	12	16	35	29.4	0.35	527	0.5
		TOTAL .	...	...	9,295	...	...	...	...	...	...	...	...	...	...	...	...	...
1/2	Det.	Aden .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1/2	9 {	Bengal—Singhbhum	...	6	1,460	24'7	24'7	...	...	...	...	...	...	...	5	23	0.5	55	1.8
		Punjab—Dungagali	70	6	274	2'37	2'37	...	...	...	...	...	...	...	28	28	0.8	130	1.3
		Aden .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		TOTAL .	...	...	1,734	...	...	...	...	...	...	...	...	...	...	...	...	...
	Det.	Tibet .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25		Tidal and Levelling .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	302(m)	II
		GRAND TOTAL .	75	...	22,496	...	...	...	...	...	...	...	...	...	...	...	...	4	

Trigonometrical stations connected with.

Permanent bench-marks embedded.

Spirit-level stations.

old Parties during the year 1903-04.

REMARKS.

- (f) Includes 96 sq. miles of re-survey in North Coimbatore.
 - (g) Includes 35 sq. miles of overlap.
 - (h) Excludes 253 sq. miles of detail survey and 11 miles of test lines not finally passed.
 - (i) Included in 4-inch traversing.
 - (j) Consists of—
Multán = 2,669 sq. miles.
Amritsar = 421 sq. miles.
Bahá walpur State = 82 sq. miles.
 - (k) Includes 455 sq. miles of Supplementary Survey.
 - (l) Includes 2,704 sq. miles of Supplementary Survey.
 - (m) Double levelling.

Statement showing the cost-rates of work executed by the

Number of Party.	Nature and locale of field operations.	COST-RATE PER SQUARE MILE.									
		Triangulation.	Traversing.	Detail survey and preparation of maps on scales of							
				1"	2"	4"	6"	8"	16"	48" & 12"	64"
	Topographical Surveys.			R	R	R	R	R	R	R	R
I	Central Provinces . . . . .	...	...	...	...	10'8	...	...	...	...	...
3	Lower and Upper Burma (New Survey).	10'8	12'9	20'3	...	...	...	...	...	...	...
	Lower and Upper Burma (Supplementary Topographical Survey).	...	...	16'0	...	...	...	...	...	...	...
10	Upper Burma	10'5	10'7(e)	27'3	...	...	...	...	...	...	...
	(Supplementary Topographical Survey).	...	...	26'1	...	...	...	...	...	...	...
II	Upper Burma	10'0	...	25'3	...	...	...	...	...	...	...
Bengal Surveys.	Bhágalpur . . . . .	...	25'6	...	...	16'8	...	...	...	...	...
	Purnea . . . . .	...	16'4	...	...	13'5	...	...	...	...	...
12	Sind	3'2	10'0	...	13'8	...	...	...	...	...	...
	Berar	5'0	10'2	...	...	...	...	...	...	...	...
14	United Provinces of Agra and Oudh	2'6	17'4	...	9'8	...	...	...	...	...	...
15	North-Western Frontier	7'5	{ 59'5 } 7'5 5'2	...	53'4	...	...	...	...	...	250'3
18	Punjab . . . . .	...		...	...	8'7	14'1	...	...	...	...
	" Supplementary . . . . .	...		5'9	...	8'4	...	...	...	...	...
	Forest Surveys.										
	Bengal	4'4	15'9(e)	...	...	64'0	...	...	...	...	...
	Gáro Hills, etc.	6'3	39'7(e)	...	...	85'2	...	...	...	...	...
9	Lahore, etc.	2'2	3'5(e)	...	...	25'0	...	...	...	...	...
	Naini Tal	7'7	23'9(e)	...	...	27'1	...	...	...	...	...
	Hoshangabad . . . . .	...	...	...	...	57'6	...	...	...	...	...
	Burma	8'7	13'2(e)	...	...	90'7	...	...	...	...	...
17	Bombay	15'3	...	...	...	67'5	...	138'8	...	...	...
19	Madras	9'2	19'5	...	...	102'2	...	...	...	...	...
20	Burma	7'4	44'5	...	...	135'7	...	...	...	...	...
	Cadastral Surveys.										
	Bhágalpur . . . . .	...	35'8	...	...	...	...	...	56'6	...	...
	Purnea . . . . .	...	26'6	...	...	...	...	...	64'9	...	...
4	Backerganj . . . . .	...	57'1	...	...	...	...	...	96'5	...	...
	Ranchi . . . . .	...	32'0	...	...	...	...	...	57'8	...	...
	Singhbhum . . . . .	...	33'6	...	...	...	...	...	...	...	...
7	Pakôkku . . . . .	...	59'7	...	...	...	...	...	274'2	...	...
	" Town Survey . . . . .	...	...	...	...	...	...	...	...	...	1,830'5(h)
	Moradabad . . . . .	...	33'7	...	...	...	...	...	46'9	...	...
	Hamírpur . . . . .	...	...	...	...	...	...	...	40'5	...	...
8	Bânda . . . . .	...	...	...	...	...	...	...	30'4	...	...
	Háthras, Sikandra Rao, Atrauli Town Survey.	...	...	...	...	...	...	...	...	...	2,974'7
	Tânda Khas Town Survey . . . . .	...	...	...	...	...	...	...	...	...	3,020'9
Detach- ment.	Godávari . . . . .	...	38'4	...	...	...	...	...	110'4	...	...

TABULAR STATEMENTS.

field parties during the year 1903-04.

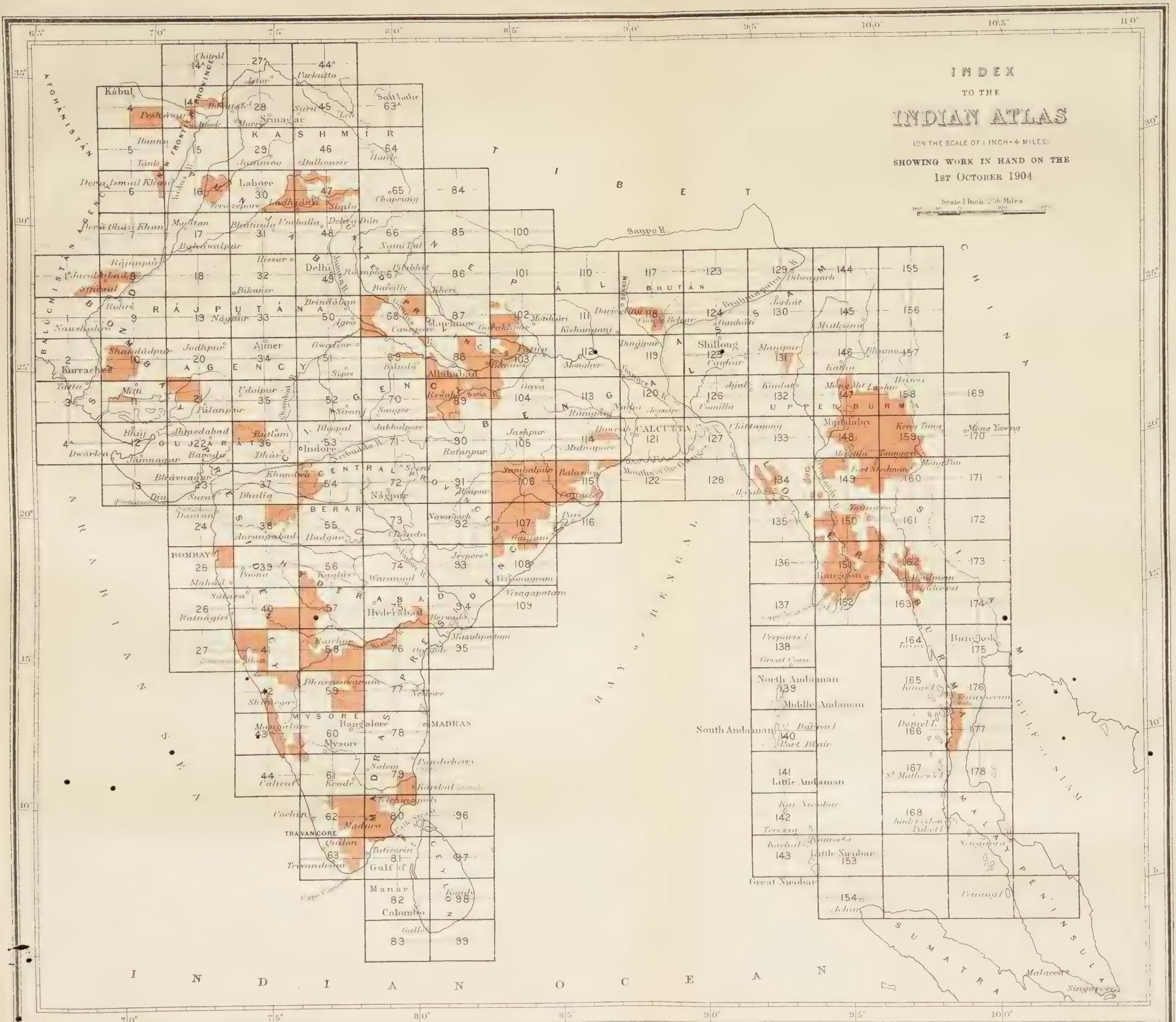
Cost-rate per acre cadastral survey including traversing, detail survey and mapping.	COST-RATE PER SQUARE MILE.			Total cost inclusive of charges for instruments to Provincial Governments.	REMARKS.
	Stone embedding.	Records (Khanapuri).	Completion of vernacular records, assessment statistics, etc.		
R a. . p.	R	R	R	R	
...	49,388	(a) Cost included under head Cadastral Survey.
...	98,679	(b) Includes R17,170 expended on mapping and bringing up arrears of work.
...		(c) Includes R5,684 expended on arrears of mapping; and on leave pay of officers and Drawing Office charge of Superintendent's pay.
...	100,499	(d) Includes R9,444 expended on supplementary traversing; R1,760 on Simla City Survey; R582 on Ferozepore revision Survey; R18,679 on arrears and mapping; R1,250 on 6-inch Survey in Simla District.
...	124,162	(e) Rate per linear mile.
...		(f) Includes R3,405 expended on 16-inch Survey of Matheran Hill Station.
...		(g) Includes R1,771 expended on mapping and publication.
...	82,712	(h) Exclusive of printing of maps.
...		(i) Includes R2,752 expended on compensation for damages done to crops during triangulation in the previous season.
...	91,481(b)	
...	120,912(c)	
...	95,775(d)	
...		
...	23,501	
...	30,955	
...	6,125	
...	969	
...	144	
...	62,880	
...	74,594(f)	
...	107,701	
...	139,510(g)	
...		
...	26·1	...	...
...	36·6	...	...
...	30·9	...	...	696,866	
...	35·4	...	...
...		
...	16·4	...	...	206,680	
...		
...	4·5	17·6	...		
...	...	13·5	...		
...	...	10·6	...	120,392	
...		
...		
...	...	3·8	...	23,900(i)	

Statement showing cost of Scientific Parties, Survey of India for Survey Year 1903-04.

Number of Party.	Name of Party.	NATURE OF SCIENTIFIC WORK.								Total cost of Party.	REMARKS.
		Astronomical determinations.	Determinations of gravity.	Principal Triangulation.	Tidal Observatories.	Preparation of Tide Tables.	Levelling Operations.	Magnetic Observatories.	Magnetic field work.		
22	Astronomical . . .	13,262	...	...	...	...	...	...	...	13,262	
23	Pendulum . . .	24,656	...	...	...	...	...	...	...	24,656	
24	Triangulation . . .	62,322	...	...	...	...	...	...	...	62,322	
25	Tidal and Levelling . . .	20,925	19,408	22,263	...	...	...	...	...	62,596	
26	Magnetic . . .	...	...	...	...	...	...	7,719	63,492	71,211	

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

6
35°
30°
25°
20°
15°
10°
5°



P.L.V. 1.3.1.3 - 3 - A - Director of Major E. B. Longe R.E. Officially Surgeon-General of India

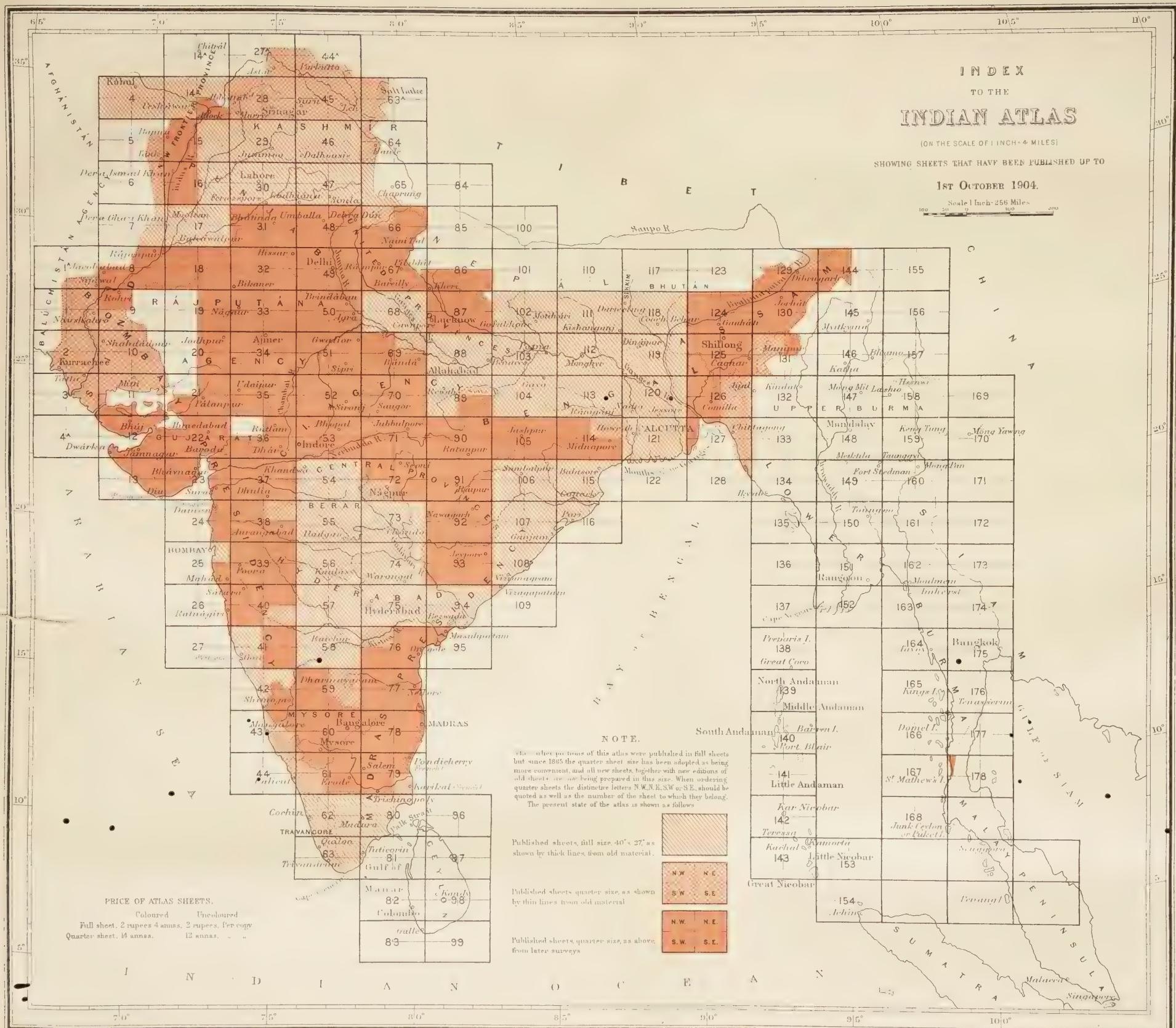
July, 1902

Nº 639 - S. 1902.

Litho., S. I. O. Calcutta.

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

50
No. 1



APPENDIX.

*Narrative Report of Captain M. O'C. Tandy, R. E., in charge Aden Boundary Survey
Detachment, from December 1901 to July 1904.*

From December 1901 to October 1902.

The survey detachment, as detailed in the margin, was assembled at Dehra Dún on December 6th, 1901, but owing to the difficulty of obtaining 3rd class passages for the *khalásis* in through P. and O. steamers, a start could not be made from Dehra Dún till December 17th.

Lieutenant M. O'C. Tandy, R.E.
Sub-Surveyor Lal Singh.
" Surveyor Mohamed Latif.
25 *Khalásis*.
The detachment arrived in Bombay on December 19th, where it was met by Colonel Wahab, C.I.E., R.E., the British Commissioner, and two days later it embarked on the P. and O. *Oriental* reaching Aden on the morning of December 26th. The *khalásis*, who were not allowed to land till the 27th, were at once taken to the quarantine island where they were detained till the 30th, the two sub-surveyors were allowed to land on the 26th, but had to attend daily at the hospital for medical inspection till the 30th; quarters were provided for the party in an unoccupied barrack in the isthmus.

Owing to the non-arrival of the Turkish Commissioners a somewhat protracted stay in Aden seemed probable, and as it was also doubtful whether work would be commenced from the northern end of the proposed boundary line or from the sea-coast working northwards, Colonel Wahab decided to seize the opportunity to visit some of the Sheikhs along the coast; the R. I. M. S. *Minto* was placed at his disposal for this purpose, and the officer in charge with Sub-surveyor Lal Singh and some *khalásis* accompanied him; landings were made at four points from 50 to 80 miles west of Aden; owing to the shelving nature of the coast, landing was never easy and took a considerable time, and as only one night was spent on shore, it was never possible to penetrate far from the coast; one intersected point of the 1892 survey was visited, and some triangulation was done from this and from one new station on the coast, and in addition a few miles of the coast line were plane-tabled on the $\frac{1}{2}$ -inch scale. The party returned to Aden on January 12th.

On January 18th the Commission marched inland, it having been decided to commence work at the northern end of the boundary; on the 26th the Commission arrived at Dthala about 80 miles north of Aden where it had settled to meet the Turkish Commissioners; the road lay entirely through country already surveyed, so no new work was done *en-route* although for purposes of identification two old trigonometrical stations were visited.

It being considered desirable to have a larger scale map than the existing $\frac{1}{2}$ -inch one of the Dthala plateau and its approaches, Sub-surveyor Mohamed Latif was left on the 24th, two marches south of Dthala with instructions to resurvey on the 1-inch scale up to Dthala, and on the arrival of the Commission at Dthala, Sub-surveyor Lal Singh commenced on the same scale the country to the north of Dthala, a few extra trigonometrical points being fixed to assist in this work.

On January 29th, the officer in charge with Sub-surveyor Lal Singh and some *khalásis* visited Harir, a hill two marches north-east of Dthala, an intersected point of the old survey but unvisited till now; triangulation was commenced here, but owing to difficulties with the local Arabs only one station could be observed from; Sub-surveyor Lal Singh plane-tabled 16 square miles of new country and in addition was able to form an idea of the topography of a much larger area including the course of the Bana river; the detachment returned to Dthala on February 2nd; on the way, J. Shairi, a trigonometrical station of the old survey, was visited, but owing to dense clouds work was impossible: at this time of year these clouds hang about the lower valleys till after midday, rising gradually as the day advances.

Both sub-surveyors continued work on the 1-inch scale round Dthala till February 10th, when the officer in charge and Sub-surveyor Lal Singh revisited J. Shairi; a round of angles was observed, but on returning to camp letters were received from Colonel Wahab, ordering the detachment to return at once to Dthala instead of proceeding to the unmapped country to the north as had been intended, as the Turkish Commissioners who had arrived near Dthala on February 10th, objected to survey work in that direction claiming that part of the country as within their sphere. On February 15th Sub-surveyor Lal Singh was sent to work on the $\frac{1}{2}$ -inch scale in new country to the south-west of Dthala, and returned on March 7th, having plane-tabled 225 square miles.

Sub-surveyor Mohamed Latif also returned to head-quarters on March 7th having completed 48 square miles on the 1-inch scale, he found work in the low country to the south very difficult; the clouds lying very low down, work in the morning was impossible, and after midday the heat was very trying.

On February 18th, a party started with the intention of visiting Huria, an intersected point of the old survey on the Radfan range; three marches to the south-east of Dthala and previously unvisited; after slight difficulty with the local Arabs, a village within 2 miles of the top of the hill was reached, but from here owing to the open hostility of the natives who fired on the party, it had to beat a hasty retreat without doing any work; this failure was a great disappointment, as from these hills a large tract of quite new country could have been surveyed; the party returned to Dthala on February 25th, dropping Sub-surveyor Mohamed Latif on the road to finish his 1-inch work. Sub-surveyor Lal Singh was able to do a few days' work on the 1-inch scale after March 7th, making his total outturn on this scale 30 square miles, but with this exception no survey work of any kind was possible from March 7th to the present date (October 9th), work in every direction being stopped either by the hostility of the natives or in deference to the wishes of the Turkish Commissioners who object to any work being done near the boundary while the present negotiations are going on.

The health of the party has been good, slight malarial fever having been the only form of sickness, and the officer in charge and a few of the *khalásis* have been the only sufferers from this.

The climate of Dthala (nearly 5,000 feet above the sea) is mild compared to that of Aden; this year during the four summer months, May to August, the average maximum temperature has been 91°, and the average minimum 65°, with a rainfall of 17 inches, chiefly in the three latter months; during these four months and also in April and September, work in the low country near the coast and at any altitude lower than this would probably be impossible, but in the Yemen highlands (7,000 feet and upwards) to the north survey work should be possible all the year round. There are no complete data for the winter months, but from October to April inclusive the average maximum temperature here is probably about 82° and the average minimum about 51°.

At first 3 and later 2 military surveyors were attached to the Commission under Major Tod of the Quarter Master General's Department; they have made reconnaissance of several roads, all within the area already surveyed.

Resumé of work done.

New country on $\frac{1}{4}$ -inch scale	:	:	:	:	:	:	.	241 square miles.
Re-survey on 1-inch scale	:	:	:	:	:	:	.	78 "

FROM AUGUST 1902—APRIL 1904.

The state of inactivity in which the last report left the Boundary Commission and which had commenced at the end of February 1902, continued until February 20th, 1903; during this long period the Commission remained halted near the town of Dthala, and the only survey work undertaken was some $5\frac{1}{2}$ square miles on the scale of 4 inches = 1 mile; this was carried out in order to show possible camping grounds and wells near Dthala in view of the arrival towards the beginning of 1903 of a small supporting column.

During this halt near Dthala the surveyors were instructed in triangulation, and Sub-surveyor Lal Singh, who had some previous experience, was able to carry out the triangulation, and, with some assistance, the computations for the above mentioned large scale survey.

On February 19th, 1903, a short visit was paid to Jabal Jihaf, a high hill some 8 miles west of Dthala, which had been previously occupied by the Turks and which they had only recently evacuated; during the two days spent on Jabal Jihaf triangulation was extended, some new work completed on the $\frac{1}{2}$ -inch scale, and the first view was obtained of the country we were subsequently to pass through. On March 21st, Sub-surveyor Lal Singh commenced the survey on the $\frac{1}{2}$ -inch scale of the Humedi country to the south and south-west of Jabal-Jihaf; on the night of the same day (March 21st) the Turks evacuated the village of Jalela, which had till then been their head-quarters, and retired to the town of Ka'taba about 10 miles to the north-west. On March 29th, the British Commissioners advanced to Sanah (a small village about $1\frac{1}{2}$ miles south of Ka'taba) in order to be near the Turkish Commissioners; this retirement of the Turkish Commission threw open to us for survey purposes, a considerable area of ground which we had not been able to visit before, and on his return from the Humedi country on April 3rd, Sub-surveyor Lal Singh commenced the survey of this on the 1-inch scale.

The triangulation had been extended as soon as we advanced to Sanah, and on April 5th, Sub-surveyor Mohamed Latif was able to commence the actual boundary survey. The Commissioners were not yet able to agree on any definite boundary line, so it was decided to carry out a survey for a distance of $2\frac{1}{2}$ kilometers on either side of the lines claimed by the respective Commissions; on account of the large amount of detail that had to be shewn, the scale of $\frac{1}{40,000}$ was settled on for this boundary work, and further as the Turks had no means of carrying on an accurate survey, it was decided that we should carry out the survey alone, frequent joint examinations of the work being made to ensure accuracy. Work was carried out on these lines from April 5th—23rd when the Turkish Commissioners refused to allow the survey to continue until they had made some references to and received orders from their Government in Constantinople. Work on the boundary was consequently stopped.

On April 27th, Sub-surveyor Lal Singh commenced surveying on the $\frac{1}{4}$ -inch scale the country to the south and south-west of Sanah near which the boundary would pass; he was joined on May 1st by the officer in charge, and triangulation and survey were carried on to the south till connection was made with the work done by Sub-surveyor Lal Singh in February 1902 and March 1903. This party returned to Sanah on May 11th.

On May 17th, Sub-surveyor Mohamed Latif left the Commission to accompany a small punitive expedition advancing against some small tribes who had recently been giving trouble on the Aden line of communication; he rejoined at Sanah on May 27th, having surveyed some 70 square miles of new country on the $\frac{1}{4}$ -inch scale. During June and July reconnaissance work on the $\frac{1}{4}$ -inch scale was carried on of all the country visible from Sanah and Jabal Jihaf. Some hundreds of points being fixed by theodolite observations from short bases of from 1 to $1\frac{1}{2}$ miles and in spite of haziness of the weather a fair idea was obtained of some 1,000 square miles of country which our surveyors are never likely to visit.

On August 31st, the entire detachment left the Commission to join a small force of 200 men and 2 guns, who were visiting the Sha'ibi country to the north-east of Sanah; this tribe occupies the top and the north and north-eastern slopes of a long range of hills running approximately east and west which had previously, with the exception of a few isolated hill tops, stopped all view to the north; there was consequently plenty of work, both triangulating and plane-tableing, to be done, and work was carried on from camp near Awabil until September 3rd; on that day Sub-surveyor Mohamed Latif when working some 5 miles to the east of Awabil with a very small escort of six men had one shot fired in his direction; acting on his instructions he at once returned to camp; the following day the surveyor continued the work in which he had been interrupted, but accompanied by an escort of 50 men with a maxim gun, work progressed peacefully till on nearing the village of Hadára, about 40 Arabs appeared in front of the party on whom they fired, firing was brisk on both sides for some moments until the Arabs retired, but not before they had shot Sub-surveyor Mohamed Latif in the head and wounded one of his escort. Mohamed Latif was a very painstaking and hardworking surveyor and his loss is greatly to be deplored. A small column proceeded on the afternoon of the 4th to destroy the village of Hádara, and again on the 7th a larger party with gun-cotton completed the work of destruction; on neither occasion was any opposition met with. By September 8th, all the survey which it was possible to do from Awabil had been finished, and it was decided to advance two marches further north into the Rube'aten country; this was done on September 9th and 10th, a column of 200 men and two guns coming up from Dthalá to occupy Awabil and keep open our line of communications; work in Rube'aten was finished on the 14th and a return was made on September 15th and 16th to Awabil. During our visit to Rube'aten the camp at Awabil was attacked from 7 A.M. to midday on the 13th by some 2,000 Arabs, who were however driven off with small loss on our side. On September 17th, the detachment returned to Sanah having surveyed about 200 square miles on the $\frac{1}{4}$ -inch scale, while with the help of many points fixed by theodolite from a short base in Rube'aten nearly 1,000 square miles was roughly sketched on the $\frac{1}{4}$ -inch scale.

On October 6th Mr. FitzMaurice and the officer in charge accompanied a Turkish column into the Mares country, and while living as the guests of the Turkish Commissioners a boundary line between Sha'ibi and Mares was agreed on and a few boundary pillars erected; for various reasons it was not considered advisable to survey this bit of country on the $\frac{1}{40,000}$ scale, accordingly an enlargement to this scale of the $\frac{1}{4}$ -inch work which had been done in the Sha'ibi country was made, and extra detail and corrections were applied to this; the party returned to Sanah on October 14th, having settled about $6\frac{1}{2}$ miles of the boundary; on October 24th work was recommenced on the boundary (scale $\frac{1}{40,000}$) where it had been left off on April 23rd, and continued without a break till November 22nd when a return to Sanah was necessary, as the Turks wished to observe Ramadan at Ka'taba. During this festival, i.e., from November 25th to December 8th, Sub-surveyor Ahmad Hussen, who had joined the detachment early in November to replace Sub-surveyor Mohamed Latif, was employed on boundary survey (scale $\frac{1}{40,000}$) in the vicinity of Ka'taba and Sanah, and from these places connected his work with that previously done on the Mares-Sha'i Ji border. On November 30th, Sub-surveyor Lal Singh left Sanah to continue the boundary survey to the south from the point where it had been left off on November 22nd.

By December 15th all boundary work near Ka'taba and Sanah had been completed, the boundary demarcated and pillars erected where necessary, so on December 16th the British Commissioners accompanied by one of the Turkish Commissioners, marched south following the course taken by Sub-surveyor Lal Singh, and halting from December 19th to 23rd near Al Husen on the Wadi Tiban, were able to examine Sub-surveyor Lal Singh's plane-table and to settle on a boundary line; meanwhile the officer in charge and Sub-surveyor Ahmad Hussen left Sanah on December 16th to revisit Jabal Harir, a trigonometrical point which had been visited in January 1902; during this second visit the triangulation carried out in Rube'aten was strengthened, a considerable area was sketched on the $\frac{1}{4}$ -inch scale, and Sub-surveyor Ahmad Hussen was able to re-survey and correct some sketch work of the 1902 survey; this detachment rejoined the Commission on December 23rd at Al Husen. On December 24th and 25th the Commission marched to the south and south-west to a camp near Ad Daréja leaving Sub-surveyor Lal Singh to follow on with the survey work; here new triangulation was required and it was not till January 9th that Surveyor Lal Singh, who had rejoined the camp at Ad Daréja on December

29th, was able to continue the boundary survey which he finished by January 22nd; it had meanwhile been decided not to continue the large scale ($\frac{1}{40,000}$) survey further south than Ad-Daréja, but work only on the $\frac{1}{2}$ -inch scale, so on December 28th Sub-surveyor Ahmad Hussen commenced this work with orders to survey a minimum of 5 miles on either side of the boundary, to join up with the 1902 survey on our side, and to survey as much on the Turkish side as was possible.

From January 1st to January 6th, triangulation was carried on from hills on the Turkish side of the boundary with Mavia as a base, and during this time a large area was sketched on the $\frac{1}{4}$ -inch scale and a considerable amount on the $\frac{1}{2}$ -inch scale.

On January 20th, the Commission marched to Hawemi, and remained in this vicinity till February 6th; during this time both surveyors were fully occupied on $\frac{1}{2}$ -inch work; it would also have been desirable to do some triangulation from some high hills near here, but unfortunately the Turks were unable to arrange this. From Hawemi owing to the hilly nature of the country, and to the want of roads and water near the boundary, the two Commissions had to separate. The British Commission marching on February 7th reached Sanawi on the 16th, having halted two or three times on the way to allow the survey to be done; on February 9th, while on the march, the Commission met with some slight opposition from a small party of Arabs, but fortunately had no casualties.

The Turkish Commission (halted about 3 miles north of Sanawi) was met on February 17th, and from that date till the 24th February both surveyors were hard at work; by the 24th, however, all survey possible from this camp had been finished and the Commissions are now waiting until orders are received from their respective Governments enabling them to settle several small disputed points, and to fix a boundary from Hawemi to Sanawi.

At intervals there has been a large amount of office work in tracing and printing copies of maps; from 6 to 8 copies of all maps made for the Commission are always required and these have been printed either on bromide paper or by ferotype process from over 50 P. O. P. negatives; in addition to maps for the Commission a large number of prints have been, from time to time, provided for the use of various supporting columns, probably 400 is an under-estimate of the total number of prints provided by the detachment.

Resumé of work done.

Scale 4 inches = 1 mile	.	.	.	.	.	.	5½	square miles.
" 1 inch = 1 "	.	.	.	.	.	180	"	"
" $\frac{1}{2}$ " = 1 "	.	.	.	.	.	1,600	"	"
$\frac{1}{40,000}$	.	.	.	.	.	140	"	"
Sketched on $\frac{1}{4}$ -inch scale	.	.	.	.	.	3,000	"	"

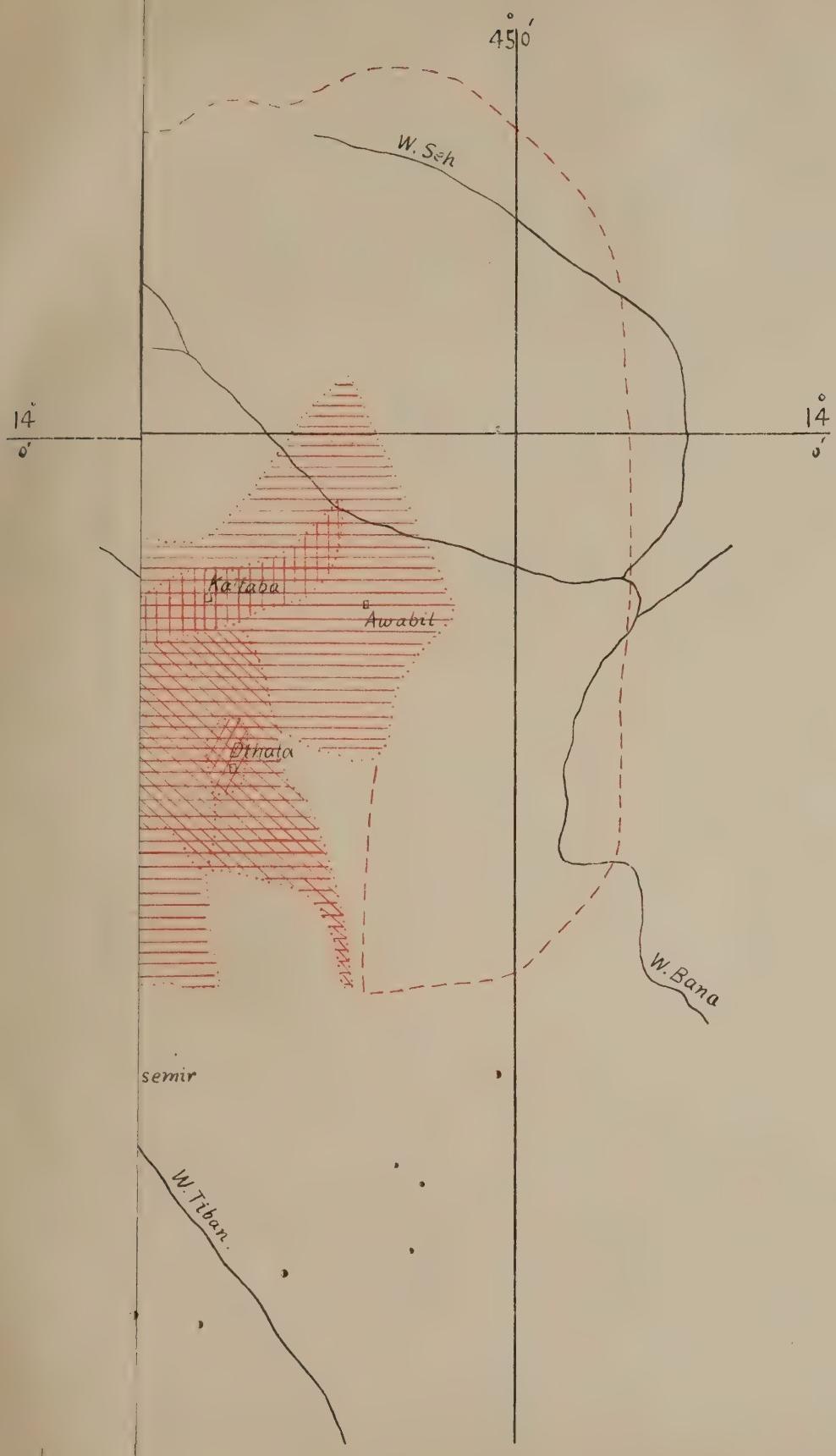
The health of the detachment during the period under report has been, on the whole, good; at the conclusion of the rains (*i.e.*, September) in 1902 there was a considerable amount of mild malaria which decreased during the cold weather, but broke out again in the spring of 1903; as a result of this malaria one *khalasi* died at Dthala, and two others had to be invalidated to India in March 1903 (one of these died within three weeks of reaching his home), while in June 1903 still another man had to be invalidated; to replace these casualties six new men were obtained from India. From the summer of 1903, the health of the detachment has been invariably good, but in December 1903 (after the Commission had been nearly two years in the country) it was considered advisable to replace 12 of the men who had been with the Commission the whole time; this was accordingly done, the new men being obtained from India.

On account of outrages committed on the lines of communication, two or three small expeditions were undertaken during the winter of 1903; it is a matter for great regret that owing to pressure of work with the Commission, no surveyor was able to accompany any of these as it is believed no survey of any sort was done, while portions of the country visited were quite new.

FROM APRIL 1904 TO JULY 1904.

As previously reported the Commission arrived at Camp Sanawi on February 16th 1904, and although all the neighbouring country had been surveyed by the end of the month, a further advance was rendered impossible through the inability of the Commissions to agree on a boundary line; this state of inactivity was very greatly to be regretted from a survey point of view, as the rapid approach of the hot weather would render survey work exceedingly trying in the low-lying country through which the remainder of our work lay; on the other hand, however, there was a great deal of office work to be done in printing copies of the surveys of the Amiri and Haushabi borders, and during this halt at Sanawi these maps were completed. On April 6th, the chief points in dispute having been settled, it was decided to continue our work in a westerly direction along the Subaihi boundary; owing to the nature of the ground it was improbable that the two Commissions, each advancing through its own territory, would meet again for several days; it was, therefore, decided to attach one of our surveyors to the Turkish Commission and Sub-surveyor Ahmad Hussen was deputed for this work.

A start was made from Sanawi on April 7th, and after three days' marching, Surveyor Lal Singh working *en route*, the British Commission reached camp in the Wadi Adim

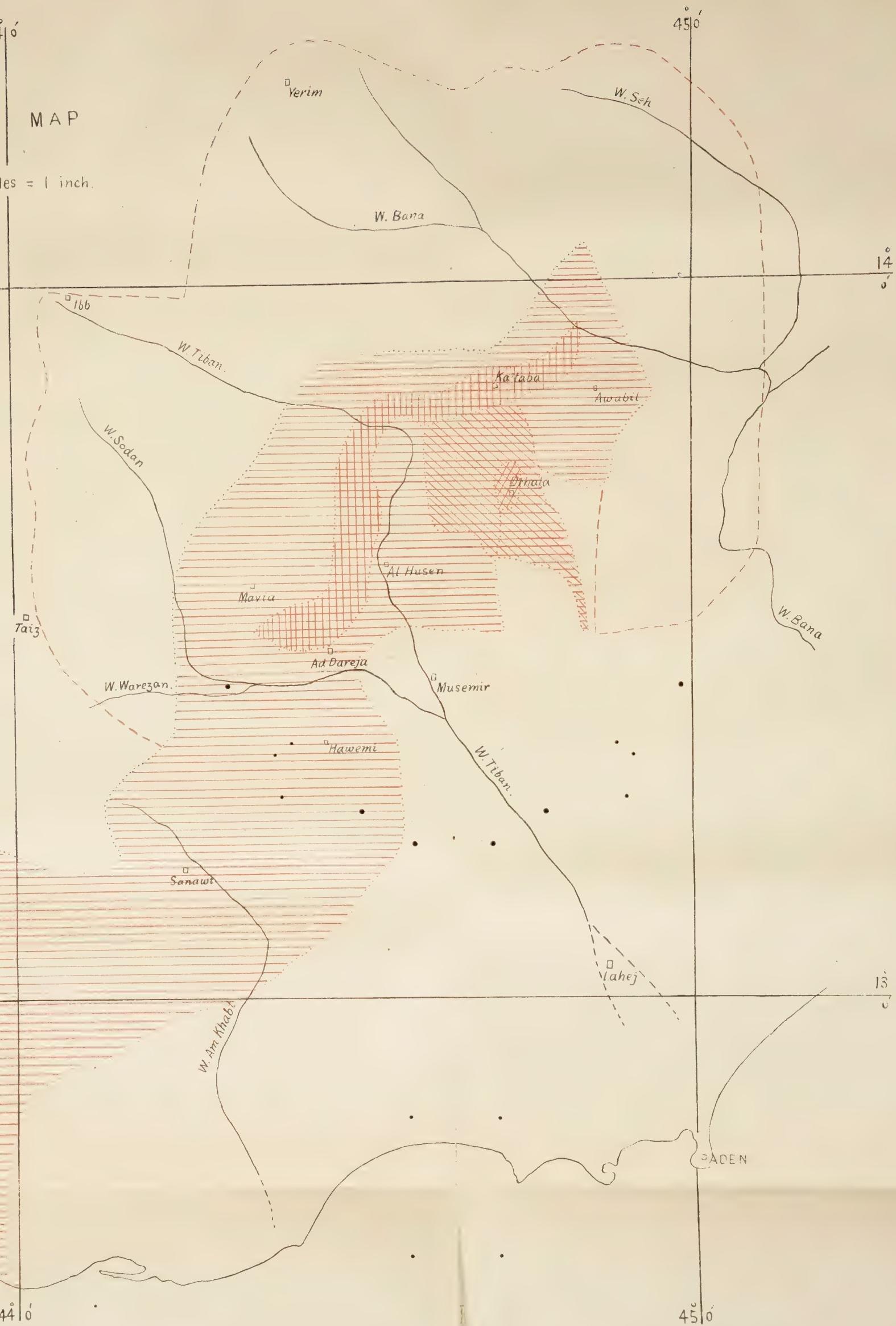


INDEX MAP

Areas Surveyed

- On $\frac{1}{2}$ " scale _____
- " 1" _____
- " $\frac{1}{40,000}$ " _____
- " 4" _____
- Sketched on $\frac{1}{4}$ " Scale _____

SCALE 10 Miles = 1 inch.



where a halt was made till the 12th. It was hoped that the Turkish Commission might meet us here, but as they failed to do so and as the water supply was both bad and insufficient, an advance was made (one march) to Mijza ; here the Commission halted till the 19th, small detached camps being sent out to allow triangulation to be extended and enable Surveyor Lal Singh to survey not only the boundary but the large unsurveyed tract of country between it and the sea. On April 19th, the Commission marched to Mudariba where it halted till the end of the month, and here, on the 22nd, we were rejoined by the Turkish Commission ; it was disappointing to find that Sub-surveyor Ahmad Hussen had been able to do very little work indeed while with the Turks ; this, however, was not his fault but was due to the inability of the Turks to allow him to leave their line of march or to visit any of the high hills which enclosed it. From April 19th, when the Commission reached Mudariba to May 10th, the survey parties were continuously away in detached camps ; Sub-surveyor Ahmad Hussen again working with the Turks, and the officer in charge and Surveyor Lal Singh continuing the triangulation and survey from camps at Turbat, April 25th—29th, Am Shat 30th, Ghail Barbar May 1st—3rd, Wadi Lassab 4th—7th, Wadi Hurim 8th—10th. By May 10th, the two Commissions were camped near Karba and here the survey parties rejoined them ; after inspecting the survey work, the Commissions decided to again separate, the Turks marching *via* Bir Huneshiya to Shekh Said, while we were to march direct to Ras' Ara and from there embark for Perim ; Sub-surveyor Ahmed Hussen still remained with the Turkish Commission while Surveyor Lal Singh worked his way down to the coast, *via* Wadi Hurim, Am Nabia and Ras'Ara. The British Commission reached Ras'Ara on May 21st, and at once embarking reached Perim on May 22nd ; on the 24th, a boat was sent back from Perim to bring off Surveyor Lal Singh who had remained at Ras'Ara to finish the survey of the coast line. On May 25th, Shekh Said was visited in order to connect up the triangulation, and at the same time Sub-surveyor Ahamad Hussen was brought back to Perim ; during his last stay with the Turkish Commission this surveyor had received considerable assistance from the Turks and had done some very useful work. The Turkish Commission being now settled at Shekh Said, and the British Commission at Perim, several meetings were held, and as the boundary line would in all probability pass through the peninsula of Shekh Said it was decided to survey it on the scale of $\frac{1}{40,000}$. Both surveyors were consequently sent to Shekh Said from the 28th—31st May. During their absence the triangulation was extended to Perim with the view of surveying the island on the 4-inch scale, the only existing maps consisting of naval charts ; this work was carried out by Surveyor Lal Singh from 1st—7th June.

From as long bases as were possible between the mainland of Shekh Said and Perim, some 15—20 points on the African coast were fixed by theodolite in the hope that they might be picked up in subsequent surveys.

The triangulated values of the latitude and longitude of Perim differed respectively by about 12" and 6" from the values on the naval charts ; it is a matter for great regret that owing to continuously cloudy weather it was impossible to obtain any satisfactory astronomical observations for latitude ; an attempt to take circum-meridian observations was made on the only clear night, but as clouds came up before the completion of the observations, these were in no way conclusive.

From June 7th—15th both surveyors were employed in office work, and in finishing up their plane-table sections ; on June 19th, leave having been obtained for the return to India of such portion of the survey detachment as could be spared, both surveyors and 15 *khalásis* sailed from Aden for Bombay, leaving the officer in charge and nine *khalásis* to finish the map drawing and to do any odd bits of survey work that might be required. This last detachment remained in Perim till July 7th by which date all the maps required by the Commissioners had been redrawn and printed, and on July 10th, it sailed from Aden with orders for the officer in charge to report to the Foreign Office in Simla.

The Officer in charge visited Dehra Dún from 20th—23rd July, in order to pay off the *khalásis* and return the instruments and stores to the Superintendent, Trigonometrical Surveys, and reported his arrival in Simla at the Foreign Office on July 25th, 1904.

An index map is attached showing the total areas surveyed.

Scale 4 inches = 1 mile	16 square miles.
" $\frac{1}{40,000}$	219 "
" 1 inch = 1 "	166 "
" $\frac{1}{2}$ " = 1 "	3,643 "
" $\frac{1}{4}$ " = 1 "	2,548 "

Preface of the Report on the identification and nomenclature of the Himalayan peaks as seen from Katmandu, Nepal, by Colonel St. G. C. Gore, C.S.I., R. E.

THE question of the name of the Indian Survey peak XV, the highest mountain in the world, is one which has given rise to considerable controversy.

When peaks are first fixed by the Survey of India they are given letters or numbers by the triangulator for purposes of identification and record. Subsequently enquiries are

made, and if a native name can be found which is really applied to the mountain in question that name is entered on the map. Failing a native name it has never been the custom of the Indian Survey to give fancy names, and the mountain remains known by its original distinguishing letter or number.

In the case however of peak XV, in 1856 Colonel Waugh, the then Surveyor General, finding no native name for the peak which on computation proved to be the highest known mountain on the globe, proposed the name "Everest," by which name it has since been known to the English-speaking world.

His Excellency the Viceroy having kindly interested himself in the matter, His Excellency Maharája Chandra Shamsher of Nepal gave permission for an officer of the Indian Survey to visit Nepal during the autumn of 1903, on purpose to identify and sketch the various peaks seen from the neighbourhood of Katmandu and try and settle the question of the identity of Gaurisankar.

Captain Wood has now visited the valley and has fully and accurately identified all the survey peaks that can be seen from the Kaulia hill, and also from the hill Mahadeo Pokra. In his report will be found a summary of the controversy which has arisen on the subject. It will be seen that the claim that peak XV should be called Gaurisankar, rests almost entirely on the evidence of Hermann Schlagintweit, who visited Katmandu in Nepal and also Falut on the ridge dividing Nepal from Sikkim. From both these places he drew panoramas of the view, and on each of these he marked a prominent peak as Gaurisankar, believing them to be one and the same peak XV. The name Gaurisankar he obtained from Maharaja Jang Bahadur of Nepal, and his pandits.

With Captain Wood's panorama of the view as seen from Kaulia before one, it is not at first evident why the Gaurisankar peak, which is in reality peak XX, should have been particularly chosen as the recipient of a name when the nearer and more striking groups to the north are nameless. The reason is, however, that from the town of Katmandu the snow mountains to the north are more or less hidden, and Gaurisankar, lying more to the east, is the most prominent of the snows visible. It has, therefore, become more familiar to the inhabitants of Katmandu than any of the other peaks.

On comparing Captain Wood's panorama taken from the top of Kaulia with that of Schlagintweit, it seems clear from the relative heights of the nearer and more distant ranges, that Schlagintweit drew his panorama from a somewhat lower elevation than Captain Wood did. This may account for the fact that the former shows no signs of peak XV (Everest) though it is visible from Kaulia as a low, insignificant peak in a gap, 2° to the right of the Gaurisankar peak. Everest is not visible at all from the valley of Katmandu, and it is only on ascending to some considerable height that its point comes into sight. In Schlagintweit's panorama, the nearer range cuts and obscures the southern slope of Gaurisankar, just at the point where the peak of Everest should have been visible.

Captain Wood gives a full account of his attempts to obtain names for the various peaks, and it is clear that the people of the country have no names which are generally associated with special peaks. The officials and those living in Katmandu, seem to have given the name Gaurisankar to the peak which is prominent from that point of view, though even this name is by no means a well known one. Whenever used it is, however, given specially to the Gaurisankar mountain and not to the group, His Excellency Mabarája Chandra Shamsher who throughout took great interest in Captain Woods's work and gave him every facility to prosecute it, giving the name Gauri to one of the points and Sankar to another. The whole evidence collected by Captain Wood is quite against the theory that Gaurisankar is a name given to the mountain mass of which peak XX, which is the prominent point, is only one peak.

There now remains the further question whether peak XV (Everest) can be called a peak of the group of which peak XX (Gaurisankar) is the most conspicuous as seen from Katmandu or its neighbourhood.

Mr. Freshfield states that the point which he has been arguing throughout is "whether the 29,002 feet peak is among the snows visible from Kakani and known as Gaurisankar." This to my mind begs the question. General Walker was mistaken when he argued that Everest could not be visible from Kaulia. He did not allow for the deep gap in the range just to the right of peak XX (Gaurisankar). Through this gap the point of Everest just appears, as seen from Kaulia. This, however, in no way proves that Everest forms part of the group of which peak XX is such a prominent point.

Captain Wood took observations and photographs both from Kaulia hill 8 miles N.W. of Katmandu, and also from Mahadeo Pokra hill 14 miles east of the town. Outlines of the Gaurisankar group from these two points carefully enlarged from photographs and on the same angular scale are herewith given. A comparison of these is instructive. In the view from Kaulia the top of Everest is shown just visible over the gap at the southern foot of peak XX. Turning to that from Mahádeo Pokra we find that the shift of point of view has had the effect of moving Everest (not very much larger although 18 miles nearer) a long way to the right and completely dissociating it from peak XX. How can this great shift be reconciled with the contention that Everest forms part of the Gaurisankar group?

The same fact could be anticipated from the study of the sketch map of eastern Nepal which is given herewith. Peak XX (Gaurisankar) is one of a great group of peaks, the principal of which are XIX and XX between 23,000 and 24,000 ft. in height. Thirty-six miles to the east of peak XX, but separated from it by the upper end of the Duh

Kosi valley, stands Everest, which with peak XIII (Makalu) forms a separate group. The two groups are joined by a ridge running round to the north over which the road passes by the Pangu-a from the Dudh Kosi valley to Dingri, but to call these two groups one and the same is to my mind quite untenable.

As showing how difficult it is to identify mountains without careful instrumental observations and calculation, it may be interesting to check Mr. Schlagintweit's identifications as entered by him on his panorama.

Schlagintweit's Identification.	True identification.	ERROR.	
		Direction.	Miles.
Gaurisánkar XV	XX	2°	36
Sankósi Peak XXI	XXI	Correct	...
Jibjibía East Peak XXII	XXIV	$7\frac{1}{2}^{\circ}$	3
Central Peak XXIV	S ₃₁	$5\frac{1}{2}^{\circ}$	5
Daibúng XXV	XXV	Correct	...
'Aku S. Peak XXVII	No such high peak exists where shown.		
Yássa N. Peak XXX	S ₁₂	34°	34
" S. " XXVIII	S ₈	33°	20
Dhavalagíri XLII	M _a	25°	74
Narayáni LI	XXX	24°	81
Machipúcha XLVII	XXVIII	22°	83

I cannot account for the lofty peak which Mr. Schlagintweit drew and named 'Aku South peak. There is no trace of such a peak in reality.

It may be further noted that the peaks (XX and XIII) seen by Schlagintweit from Kaulia and Falut which he considered one and the same and named Gaurisankar, are no less than 47 miles apart.

As to Dr. Boeck's photographs and identifications which Mr. Freshfield brings forward as giving additional evidence on the point of the visibility of Everest from Kaulia, a comparison of Captain Wood's photographs with the enlargement of Dr. Boeck's photograph published in the Geographical journal, clearly shows that the peak he calls Gaurisankar, and which Mr. Freshfield thinks he can hardly be wrong in recognising as XVIII is in reality XXIV, a peak more than 30° to the left of the real direction of XVIII. If Dr. Boeck started on his identifications with this peak as Gaurisankar, it is not surprising that he found plenty of peaks more to his right to identify as Kanchinjinga, Kábru, etc.

I am afraid that those who trust to their appreciation of characteristic forms and their mountaineering instincts, as a means of identifying peaks from widely different points of view are apt to be frequently misled.

The conclusion which, on consideration of all the evidence, I have arrived at is that while there is no ground whatever for giving the name Gaurisankar to Mount Everest, there seems to be perhaps sufficient accord in the Nepalese designations to warrant our acceptance of that name for peak XX.

Report on the identification and nomenclature of the Himalayan Peaks, as seen from Katmandu, Nepal, by Captain H. Wood, R.E.

In 1856, when the then Surveyor General Colonel (afterwards General Sir) A. Waugh proposed the name of "Mont Everest" for Peak XV of the Great Trigonometrical Survey of India's list of the great Himalayan Peaks, the suggestion gave rise in geographical circles to considerable discussion as to whether this peak had a native name, and if so, what that name was, and this discussion has been renewed at intervals. Sir A. Waugh proposed first to the Government of India and then to the Royal Geographical Society in London to give to this peak the name of his predecessor in office, because, though he had always scrupulously adhered to the rule of assigning to every geographical object its true local or native appellation, the Survey officers had not been able to discover, nor were they likely to be able to do so, any local name, and that as it was probably the highest mountain in the world, he had decided to name it after his late chief and to show that it was the peak alone that was so named and not the range he prefixed the word Mont and not Mount.

Six months later Mr. Hodgson, who was for 20 years Political Resident in Nepal, informed the Asiatic Society and also the Royal Geographical Society that the peak was not nameless, but that it was known in Nepal as Devadhungha. The former Society accepted the name Devadhungha and repudiated Everest. Thereupon Sir A. Waugh convened a committee of four officers to report on the matter, and their decision was published in the Proceedings of the Royal Geographical Society, Vol. 2, 1858. They decided that the identity between Everest and Devadhungha was not only not established but was also far from probable, and that Mr. Hodgson had written under the belief that the peak was so remarkable a feature that it would not have been creditable to him after 20 years' residence in Nepal had he been unable to identify it, but remarkable as the peak was from some points of view, from the parts of Nepal where Europeans were permitted to visit, the peak would probably be hidden by an intervening mass of mountains. The discussion

then dropped till 1862 when the Messrs. Schlagintweit published Vol. II, Hypsometry of their "Results of a Scientific Mission to India and High Asia." From this it appears that Hermann Schlagintweit from a point (Falut) on the Singhalila range (on the Sikkim Frontier) saw a very high snow peak in Nepal, and that in 1857 when he visited Nepal, he recognized this peak from a station, Kaulia—a point on the Kukani range, a few miles north-west of Katmandu—and that in Nepal this peak was called Gaurisankar, its Tibetan name being Chingopamari. This peak he stated was the one called Everest. In Vol. III he further remarks that prior to his visit to Nepal, Mr. Hodgson had made enquiries for him in Darjeeling about the name of this peak, and that the Nepalese called it Devadhungha, Bairabthan, Bairablangur, and the Tibetans Gualham, Taghlo Gualham and Taghlo, but that when he saw it from Kaulia every one called it Gaurisankar, and when questioned as to the other names they had given Mr. Hodgson, they averred they had not clearly understood which peak was meant.

Thereupon General Walker, R.E. (late Surveyor General), and, General Tennant, R.E., from Hermann Schlagintweit's panoramic profile of the snows from Kaulia and a chart of the geographical positions of the principal peaks and of Kaulia as given in Part II of the Schlagintweit Atlas, proved (assuming Schlagintweit's positions to be correct) by comparing the computed and observed azimuths that Everest and Gaurisankar were not one and the same peak. Their results were published by General Walker in the February Number of the Geographical Society's Journal for 1886 under the title "Notes on Mount Everest." At the same time Colonel Tanner, I.S.C. (of the Survey of India Department) published a paper in the Alpine Journal (February Number of 1886) on "The Highest Peak of the Himalayas." To this the Honorary Secretary of the Royal Geographical Society (Mr. D. W. Freshfield) added an appendix in which he decided that the peak called Everest was one and the same as seen by Hermann Schlagintweit and ascertained to be Gaurisankar and that the English designation Everest should be rejected. General Walker replied, but Mr. Freshfield remained unconvinced, and the matter remained unsettled as before.

In Petermann's Mitteilungen No. II of 1888 Emil Schlagintweit (brother of Hermann), wrote an article "Über den Namen des höchsten Berges der Erde," in which he gave a summary of the discussions which had taken place before this date, and also a learned dissertation on the meanings of the various names that had been suggested for the highest snow peak of Nepal, and he ended by suggesting Gaurisankar-Everest as the name for it. This article was translated into English and published with a reply by Colonel Tanner, together with several panoramas, by the Survey of India as a departmental paper and entitled "A few lines on Mount Everest." In this paper Colonel Tanner again maintained that Gaurisankar and Everest cannot be the same peak. This was replied to by Emil Schlagintweit in Petermann's Mitteilungen No. 10 of 1890 under the same title as his previous article. Nothing new was brought forward by him but he still was unconvinced and again pressed that the name Gaurisankar be used by the Survey of India in lieu of Everest.

The controversy then dropped till 1898 when Major Waddell, I.M.S., in an article in the Royal Geographical Society's Journal, Vol. XIII, discussed the naming of Everest and suggested a Tibetan name for the peak. To this Emil Schlagintweit replied in Petermann's Mitteilungen No. 2 of 1901. He gave another learned dissertation on the meanings of the Tibetan names, and though no new evidence was produced, he again repeated his proposals to call the peak Gaurisankar-Everest, though virtually admitting that the name of Gaurisankar is applied to the group and not to the peak.

No other article on this subject appears to have been written until March 1903, when in the Royal Geographical Society's Journal of that month Mr. Freshfield published an article "The Highest Mountain in the world." In this article a reproduction of a tele-photograph from "Durch Indien im verschlossen Land Nepal" by Dr. Boeck is published. In this photo there is a peak which Mr. Freshfield identifies as No. XVIII, and over the northern flank of it appears a snowy mountain which he takes to be the peak XV (Everest). The highest point of this group was pointed out to Dr. Boeck as Gaurisankar, and Mr. Freshfield concludes by saying "I trust I have made it clear that the point I have been arguing throughout is whether the 29,002 ft. peak is among the snows visible from Kukani and known as Gaurisankar, and not whether Schlagintweit or Major Wilson or other observers have identified rightly the particular summit."

This is hardly in accordance with Mr. Freshfield's previous writings as in Schlagintweit's note "Über den Namen, etc." published in Petermann's Mitteilungen No. II of 1888, he stated referring to Mr. Freshfield's appendix to Colonel Tanner's article in the Alpine Journal, that Mr. Freshfield established that the peak named Everest was one and the same as the one seen by Hermann and ascertained to be Gaurisankar.

Previous to the publication of this article Colonel Gore, R.E., C.S.I., Surveyor General of India, had interested His Excellency the Viceroy in the matter, and represented to him that the question could only be finally settled by sending an officer into Nepal with the necessary instruments for taking observations.

The Prime Minister of Nepal was, therefore, approached on the subject, and the Durbar having given permission for an officer of the Survey of India to visit the hills round Katmandu and to take the necessary observations I was deputed for the duty.

My instructions from the Surveyor General were to first visit one of the Great Trigonometrical Survey stations in the plains of Bengal to the immediate south of Katmandu,

from which the higher snow peaks had been fixed (Batwaia) T. S., Lat. $26^{\circ} 49' 51''$, Long. $84^{\circ} 59' 2''$, was the one selected) and from there to identify by means of their azimuths the various fixed peaks and to make sketches of them. I was then to march to Nepal watching the peaks when they were visible to notice the change in their appearance, and from Kaulia or—if that hill could not be identified—from some other of the peaks on the Kukani range observe an azimuth, and by interpolation with the theodolite from the peaks west of No. XXII, which I was able to recognize, obtain my position, checking this by an observed latitude. With the co-ordinates of the point of observation thus obtained and those of all the Everest Group, I could work out the true azimuths of all and identify the peaks by means of setting the theodolite on the peaks in succession, and could check this identification by observing the vertical angles and working out their heights. I also was to make a panorama using the theodolite to plot all the prominent peaks, by measuring horizontal and vertical angles and filling in the detail by hand or, if permitted, by photographs. The names given by the country people to the groups or peaks were to be obtained, if possible.

I left Mussooree on the 2nd October reaching Segowlie on the evening of the 4th, accompanied by 1 native sub-surveyor and 14 *khalásis*, and took the following instruments. One 6-inch theodolite with stand by Messrs. Troughton and Simms (the limbs were read by 2 micrometers graduated to $10''$ but which could be easily estimated to $1''$), one Telescope by Messrs. T. Cooke and Sons with 3-inch object glass and fitted with pancreatic eyepiece, 2 sidereal chronometers, 2 plane-tables with their fittings, 2 aneroids with $3''$ dials, 2 thermometers, 1 Zeiss binocular telescope (prismatic), 2 field glasses, 1 whole plate camera with lenses of varying focus, and the necessary materials for developing the negatives and taking rough prints—also drawing instruments, rulers, papers, etc.

Unfortunately, early in October, an unseasonable cyclone which visited the eastern and central parts of India, giving large amounts of rain, flooded the country between Segowlie and Batwaia breaching the road in several places and making it very difficult to traverse. Though I left Segowlie early on 5th October, it was not till the 9th after many hardships and long marches that I arrived at Batwaia, though in ordinary times the march can be done in one day. Owing to the cloudy weather it was not until the 13th October that any view of the snows was obtainable, and then for only about half an hour at sunrise when a few of the peaks to the north were visible. Again on the following day at the same time they showed up but not very clearly. However, I was able to identify on the two days peaks Nos. XXII—XXX and XXXIII—XXXV, and to make rough hand sketches of them so as to fix their appearance in my memory. Those peaks lying to the north and north-west did not alter much in appearance as I advanced into Nepal, and were easily recognizable when seen from the hills round Katmandu. The delay at Batwaia re-acted on the work throughout as it was necessary that I should leave Nepal before the departure of the Resident about 15th November. Leaving Batwaia on the 14th October, I reached Katmandu on the 21st, and after a halt of one day there to collect coolies and to discuss the best places to visit with the Resident, I proceeded to Kaulia on the morning of 23rd. To understand the positions of the various places in the Nepal valley mentioned later on, it is necessary here to make a short digression to describe the valley. The Nepal valley is roughly elliptical in shape, about 20 miles in length by 12 in width, with its longer diameter lying approximately in a east-west direction. Katmandu can be considered to lie at the western focus of the ellipse. The valley is surrounded by a chain of hills, and for all practical purposes they can be considered as one range rising at places to peaks 7,000—8,000 feet high with low passes in between. Taking these peaks in order :—to the west lies Mount Nagarjun; to the north-west the Kukani range; to the north Sheopuri; north-east Manichur; east Mahadeo Pokra and south-east Phul Chowk (the highest of all the peaks surrounding the valley). The southern peaks do not come into this question and are not referred to here. The Kukani range consists of two peaks, the higher one Tokah lying to the east and joining on to Sheopuri, while the lower one to the west is called Kaulia. The lower slopes of Kaulia lie rather behind Nagarjun, and this hill cuts off the view from Kaulia of the western part of Katmandu. Kukani—the village from which the range takes its name and where a bungalow belonging to the Resident is situated—lies on a small elevation on the eastern slopes of the col connecting Kaulia and Tokah. This bungalow was built in 1869 or 1870, and replaced one situated almost on the summit of Kaulia, which was built during the time Mr. Hodgson was Resident—probably about 1824—and which was destroyed after the new bungalow at Kukani was built. The foundations of the walls of the old bungalow at Kaulia can still be traced, and it is most probably this bungalow which is mentioned by Hermann Schlagintweit as being close to his point of observation at Kaulia. With the view to occupying a position as near as possible to Schlagintweit's station I decided on observing from the highest point of the Kaulia hill, though this did not give the best view of the snows—Sheopuri being undoubtedly a better site. I had no difficulty with the aid of the sketches made at Batwaia, in identifying peaks XXII, XXIV—XXVIII, XXX and the more western ones XXXIII—XXXVI with the aid of my projected plane-table. I took latitude and azimuth observations on 3 nights. For the latitude on each night 8 to 12 observations were taken both to Polaris and to a south star at transit and for the azimuth 4 observations on each of 2 different zeros were made each night to Polaris and to ζ Ursae Minoris when they were near their eastern and western elongations respectively. Time was obtained each night by observing stars to the east and west close to the prime vertical. The results of the observations are given in the appendix. In the early morning and evening, spread over 3 days, 4 measures were made on each of 4 zeros of the angles between the peaks XXII, XXIV, XXV, XXVII,

XXVIII, XXX and the azimuthal referring mark; vertical angular measurements also were made to these peaks on the same days. These peaks were selected to interpolate my position from as I had not the slightest doubt of their identification and their summits offered the best points for intersection.

On the completion of the observations, the astronomical latitude and the azimuth of the referring mark were computed, and by applying the angle between the referring mark and the various peaks the azimuth of the peaks themselves obtained.

Then by taking from the plane-table the distances between the point of observation and the peaks, and using the astronomical latitude and azimuth, an approximate ΔA^* for each peak was computed, and thus the approximate azimuth of Kaulia (the point of observation) from each peak obtained.

As the distances between and the azimuths of each peak from the others had been already computed, an approximate value of the angle subtended at any peak between Kaulia and any other peak could be obtained.

The 6 selected peaks were then divided into 2 groups—XXII, XXV, XXVIII, and XXIV, XXVII, XXX, and from each group 3 sets of 2 triangles were formed to give a double value for each of the sides of the triangles—then using in successive triangles the approximate value of the angles subtended at each peak by Kaulia and the other peaks of the group, and the observed value of the angles at Kaulia between the peaks, values for the common sides were obtained. Considering the change in log-sine to be proportionate to the change in the angle, the approximate angles at the peak were corrected, so that the value of the common side obtained from each triangle should be the same. The computation was then made a second time, but the corrected angles were used in the places of the approximate ones, and a second approximation was obtained and the angles again corrected. A double value of each angle was thus obtained (one obtained directly by the computation and the second by subtracting the sum of the other 2 angles of the triangle obtained in the duplicate triangle from 180°). The mean of these 2 angles was accepted as correct. The Spherical excess of each triangle was then computed and applied to the angles of the triangle, and the 3 triangles of each group computed with these corrected angles, double values for each side being obtained; the mean being accepted as correct. With these values and the mean azimuth of Kaulia at each peak (obtained by applying the spherical angles (obtained from the computations) at any peak between Kaulia and the other 2 peaks to the azimuth of each of these peaks), the latitude and longitude of Kaulia were computed. Six values were obtained, each group of 3 being absolutely independent of the other, and the mean was accepted as correct. The close accordance of the values (*vide Appendix*) prove that no mistake had been made in the identification of the 6 peaks employed. Using the measured vertical angles and the computed distances of the peaks, and taking the co-efficient of refraction as 0.75 † the height of Kaulia was obtained, the mean of the 6 values being considered correct. With the computed co-ordinates of Kaulia and the co-ordinates of peaks XV, XVIII, XIX, XX, XXI, (peaks XVI, XVII were undoubtedly not visible), the true azimuth of each was worked out. The theodolite was then set at the required azimuth and vertical angles taken to the peak to which the theodolite pointed. By these means peaks XV, XVIII, XX, and XXI were identified. Peak XIX was not visible. Subsequently further peaks were identified, for particulars *vide Appendix I*. While these computations were being done, vertical and horizontal angles were measured on both faces with the theodolite to every snow peak visible, prominent or the reverse, and to most of their depressions, and changes of slopes and on one face to all the peaks, knolls, depressions, changes of slopes, etc., of the intermediate ranges. Photographs had also been taken at various hours of the day, some before sunrise and some just at, or after sunset, and some during the middle of the day. The positions of all the peaks, etc., obtained by the theodolite over 500 in number were then plotted on a prepared sheet of drawing paper. The cylindrical projection was used and a scale of $2^\circ = 1$ inch employed, and by means of the plotted positions of the principal peaks, etc., and of the photographs, a panorama of all the snows visible was drawn. This was then studied on the spot and, with the aid of the large telescope, the outline examined, and where necessary, re-drawn. Enlarged panoramas of the Gaurisankar group and peak XXIV were also made on the scale of $1^\circ = 2$ inches.

The work at Kaulia was finished on 5th November and the hill left that day. I then proceeded to Mahadeo Pokra from which point, I was informed by the Resident, the best view of the snows was obtainable, and similar observations to those taken at Kaulia were made and reduced. The only difference being that the observations were made on 2 days in place of 3, and that peak XXVI was used in place of XXII. The groups were arranged thus:—XXIV, XXVI, XXX, XXV, XXVII, XXVIII. This formed an entirely different grouping to that employed at Kaulia and was done as an additional proof of the correct identification, as, Kaulia being visible from Mahadeo Pokra, the observed azimuth of it could be compared with the one computed from the accepted positions of the 2 points.

From the value obtained for the place of observation, at Mahadeo Pokra, the following peaks were identified, XV, XVII, XVIII, XIX, XX, XXI, XXIII, etc. (*vide Appendix 2*).

The points of observation at Kaulia and Mahadeo Pokra were both marked with piles of stones and rock 6 ft. in diameter and 6 ft. high.

* If A is azimuth of peak B from peak A, and B is azimuth of peak A from peak B. Then $\Delta A = (B - 180^\circ + A)$.

† At midday the peaks were always obscured by clouds and therefore the vertical angles could not be measured at the time of minimum refraction, hence a somewhat large co-efficient was employed in the computations.

A panorama on a scale of $2^{\circ}=1$ inch was also made at Mahadeo Pokra, of all the snow peaks visible and one on the scale of $1^{\circ}=2$ inches of the peaks near XV.

His Excellency Maharaja Chandra Shamsher very kindly wrote on a photo taken from Mahadeo Pokra, from which the view to the east is very nearly the same as that from Katmandu, (after having pointed out the hill to me from the window of his palace), which peak was known to the inhabitants of the valley as Gaurisankar. From this it appears that the name Sankar is given to that identified as peak XX and Gauri or Parbati to a lower peak not fixed by the Survey of India. His Excellency particularly told me the name was applied to these 2 peaks and not to the range. Peak XV (Everest) is invisible from Katmandu, or at least I was unable to identify it from any position in the valley at which I erected the telescope, and I tried at 3 or 4 different places. Nor from Chandragirhi or Seishagarhi, the 2 passes crossed on the way from Katmandu to Segowlie, could I identify the peak even with the aid of a very good pair of field glasses, and at the former I should add that the place where I expected to see the peak (Chandragirhi-Katmandu, Mahadeo Pokra are all approximately on the same bearing) was hidden by a small cloud when I crossed the pass on my return journey.

As regards the naming of the various peaks, I could discover nothing. The name Gaurisankar appears to be one given (by the nobles at Katmandu only) to the highest peaks of the group which is the only conspicuous one seen from the city (the one marked as Gaurisankar on Schlagintweit's panorama is peak XX), and I very much doubt if they could recognize it if seen from a slightly different point of view. At least the officer His Excellency Maharaja Chandra Shamsher sent up to Kaulia to point out this peak to me failed to recognize it, and said it was not visible from there; and even after I had pointed out the peak to him he said it was not Gaurisankar but a peak something like it. Every lower class native of the valley I asked did not know the peak by that or any other name, nor did they appear to give names to any of the snows at all. At Kaulia and at Mahadeo Pokra I had several, about ten in all, hill men brought to me who were supposed to know the names of the hills, and every one, without exception, gave different names to the same peaks, and none called the peak known in the valley as Gaurisankar, by that name. Very nearly every other peak visible was pointed out as Gaurisankar when asked, but with the exception of 2 men, both at Kaulia, none give the name Gaurisankar to any peak until they were asked which was Gaurisankar. My method of questioning was to lay a straight stick (I found they could use that better than the plane-table sight ruler) on the plane-table and tell them to point it in succession to the hills whose names they knew. At first I took down the names they gave but as each gave a different one, I did not think any reliance could be put in them and discontinued doing so. The 2 men mentioned above gave the name Gaurisankar, one to peak XXIV and the other to peak XXVIII. Peak XXIV is undoubtedly the one reproduced in the March Journal of the R. G. S. of 1903 from Dr. Boeck's work, and identified by Mr. Freshfield as peak XVIII. The peak appearing over the northern shoulder, which he fancies is peak XV, is most probably one of the minor peaks fixed by the Survey of India and known as S 33 (43 miles from Kaulia and 2 miles beyond peak XXIV, height 23,360 feet), but its identification is not perfect. It disappears behind peak XXIV, when seen from Mahadeo Pokra. A comparison between the telephotograph in the Journal and the enlarged panorama made by me, or my photograph shows conclusively that they are views of one and the same point; possibly, the man who pointed out this peak to me as Gaurisankar was the same man who pointed it out to Dr. Boeck. Though from the parade ground at Katmandu, Gaurisankar (peak XX) is undoubtedly the most prominent peak visible, and from Mahadeo Pokra (about 800 ft. below the summit on the same range is Nagarkot, where the Maharaja has some bungalows which he visits during the hot months), it is an imposing mass but by no means the most striking from Kaulia, seen as it is across a mass of intervening hills, it is rather an insignificant looking peak, and peaks XXII, XXIV, the group containing XXVI and XXVII, and XXVIII, are by far more striking and imposing. Everest as can be seen from the photos both from Kaulia and Mahadeo Pokra, is the least imposing of all and, standing as it does quite apart from, and a long way behind the main range, to call it a peak of the Gaurisankar group is absurd, and there appears to be not the slightest grounds for giving it that name. From no peak on the hills surrounding the Nepal valley would any native select Everest as being the highest in the world, or even as anything like as high as the big masses visible, and it is hopeless to expect to obtain a name for this peak from the inhabitants of the valley when they are content to allow so many masses which are far more conspicuous, to remain nameless.

Appendix No. I.

Co-ordinates of Snow Peaks used in fixing Kaulia hill station.

Peak	Name of Peak.		Latitude.			Longitude.			Height in feet.
			°	'	"	°	'	"	
XXII .	.	.	28	7	40'97	85	54	43'01	21,840
XXIV .	.	.	28	10	25'06	85	49	18'48	22,880
XXV .	.	.	28	15	21'52	85	33	35'92	23,750
XXVII .	.	.	28	20	43'29	85	7	24'46	23,300
XXVIII .	.	.	28	26	2'99	84	41	0'89	25,800
XXX .	.	.	28	33	0'29	84	36	10'25	26,660

Mean Values of Angles measured at Kaulia hill station between the Snow Peaks.

Peak	R. M.	Name of Peak.	Horizontal Angle.			Vertical Angle.		
			°	'	"	°	'	"
	XXII	.	0	0	0			
	XXIV	.	32	39	77	E	3	20 43
"	XXV	.	40	10	38'2	E	3	53 46
"	XXVII	.	64	3	11'9	E	4	58 16
"	XXVIII	.	108	5	58'0	E	4	26 39
"	XXX	.	133	51	6'0	E	3	17 14
			132	33	27'8	E	2	51 46

Results of Observations for Latitude and Azimuth.

Date 1903.	LATITUDE.			AZIMUTH OF REFERRING MARK.					
	Star.	Latitude N.		Polaris.	Ursae Minoris.			Mean of Day.	
		°	'	"	°	'	"	°	"
Oct. 24th	Polaris	.	27	48	29'6	93	26	48'0	93 26 36'4
	α Gruis	.			21'3	52'0		37'3	{ 93 26 43'43
" 26th	Polaris	.			25'3	45'6		44'2	
	γ Gruis	.			23'8	52'0		41'3	{ 45'77
" 27th	Polaris	.			26'9	37'1		49'3	
	α Piscis Aust	.			27'6	34'1		46'5	{ 41'75
	Means	.			27° 48' 25'8"	93° 26' 44'8"		93° 26' 42'5"	93° 26' 43'65"

Azimuth of R. M. from h. s.=273° 26' 43'7".

Mean Computed Distances and Azimuths.

Object.	DISTANCE.			Azimuth.	
	Log feet.	Miles.	°	'	"
To Kaulia h. s. from Peak					
XXII	5'3678987	44'184	61	4	22
XXIV	5'3381499	41'259	53	31	38
XXV	5'2638645	34'772	29	30	28
XXVII	5'2984811	37'057	345	16	47
XXVIII	5'4708005	56'005	319	18	0
XXX	5'5372321	65'253	320	34	41

Resulting Co-ordinates for Kaulia hill station.

Peak	XXII	XXIV	XXV	XXVII	XXVIII	XXX	Computed from.			Latitude.	Longitude.	Height in feet.
							°	'	"	°	'	"
							27	48	58'31	85	16	48'78
									58'87		47'34	7,088
									58'31		48'75	7,069
									58'79		47'16	7,085
									58'39		48'50	7,033
									58'82		46'89	7,026
Mean	27° 48' 58'6"			85° 16' 47'9"		7,051

Observed Latitude=27° 48' 25'8"
 Computed " =27° 48' 58'6"
 ∴ O-C = -32'8"

Results of Identification of Snow Peaks.

Name of Peak.	Latitude.	Longitude.	AZIMUTH.		HEIGHT.	
			Computed.	Observed.	Computed.	Observed.
Peak XV . . .	27 59 16'22"	86 58 7'09"	263 4 51	263 4 14	29,002	28,764
" XVIII . . .	27 52 50'52"	86 31 58'62"	266 23 49	266 23 10	21,980	21,870
" IX . . .	27 57 51'97"	86 22 43'27"	261 6 44	261 6 18	23,440	23,386
" XXI . . .	27 57 28'83"	86 9 8'85"	259 26 8	259 25 52	19,550	19,501
" XXXIII . . .	28 21 6'74"	85 49 21'76"	221 49 7	221 49 24	26,290	26,266
" XXXIV . . .	28 29 23'77"	84 13 57'42"	126 13 2	126 12 15	22,920	22,845
" XXXV . . .	28 32 4'99"	84 9 52'78"	126 16 48	126 16 51	26,040	25,998
" XXXV . . .	28 32 11'32"	84 7 32'33"	125 25 22	125 26 0	24,690	24,665
" XXXVII . . .	28 29 40'71"	83 59 22'12"	120 58 40	120 59 20	22,940	22,940
" XXXVIII . . .	28 29 53'64"	83 59 20'56"	121 6 10	121 6 41	22,960	22,911
" XXXIX . . .	28 35 44'31"	83 51 46'52"	122 10 12	122 10 33	26,492	26,413
" XL . . .	28 31 5'21"	83 50 55'72"	119 17 52	119 17 52	23,607	23,539
" XLVII . . .	28 40 26'10"	83 19 7'02"	116 44 41	116 44 55	23,539	23,474
" S 12 . . .	28 15 51'0	85 14 10'3	175 3 15	175 5 13	19,130	19,101
" Bi 7 . . .	28 22 45'3	85 0 0'9	164 14 12	164 13 35	23,310	23,180
" B 484 . . .	28 6 14'6	85 56 35'7	243 43 5	243 46 7	19,740	19,893
" S 31 . . .	28 10 10'0	85 43 17'7	227 52 40	227 54 12	...	...
" T 8 or S 30 . . .	28 14 59'1	85 47 32'0	226 14 11	226 14 44	...	...
" Ma . . .	28 23 27'3	84 49 55'2	145 27 5	145 27 21	...	...
" S 7 . . .	28 19 55'1	85 12 7'2	172 22 49	172 22 5	...	...
" S 8 . . .	28 19 53'8	85 12 22'0	172 46 22	172 45 56	...	...

Note on Captain Wood's identifications.

The "computed" azimuth is the true azimuth of each peak from the point of observation (Kaulia or Mahadeo Pokra), obtained by computation, using the co-ordinates of the point of observation as determined by Captain Wood and those of each peak as previously fixed by triangulation. The "observed" azimuth is that measured by Captain Wood with the theodolite from his point of observation to the peak. Similarly the "computed" height is that of each peak as previously determined by triangulation at the time the peaks were fixed, the "observed" height being that determined by Captain Wood by theodolite from his point of observations. On the agreement of these computed and observed azimuths and heights, the identification of the peaks rests. Absolute agreement is not to be expected, as the observations were taken to the more or less indefinite summits of the peaks which renders it very probable that in many cases Captain Wood did not observe exactly the same spot on each peak which was taken when the peak was originally fixed. In the case of heights no close agreement is to be expected on account of the uncertainty of the effects of refraction at these high altitudes. The agreement of the figures in Captain Wood's tables are quite sufficiently close to enable us to accept the identifications with perfect confidence.

Appendix No. 2.*Co-ordinates of Snow Peaks used in fixing Mahadeo Pokra hill station.*

Name of Peak.	Latitude.	Longitude.	Height in feet.
Peak XXIV . . .	28 10 25'06"	85 49 18'48"	22,880
" XXV . . .	28 15 21'52"	85 33 35'92"	23,750
" XXVI . . .	28 23 29'89"	85 10 12'63"	24,300
" XXVII . . .	28 20 43'29"	85 7 24'46"	23,300
" XXVIII . . .	28 26 2'99"	84 41 0'89"	25,800
" XXX . . .	28 33 0'29"	84 36 10'25"	26,660

Mean values of angles measured at Mahadeo Pokra hill station between the Snow Peaks.

Name of Peak.	Horizontal Angle.	Vertical Angle.						
			°	'	"	°	'	"
R. M.	0 0 0							
Peak XXIV . . .	63 59 33'1	E.	4	25	9			
" XXV . . .	89 42 38'9	E.	4	23	28			
" XXVI . . .	115 50 8'3	E.	3	8	2			
" XXVII . . .	120 10 12'8	E.	3	1	34			
" XXVIII . . .	135 39 29'6	E.	2	16	36			
" XXX . . .	133 59 19'1	E.	2	2	30			

Results of observations for Latitude and Azimuth.

DATE 1903.	LATITUDE.			AZIMUTH OF REFERRING MARK.			
	Star.	Latitude N.	Polaris.	ζ Ursae Minoris.	Mean of a day.		
Nov. 7th.	Polaris . . .	27° 40' 54"3	89° 25' 64"1	89° 25' 46"8	89° 25' 56"55		
" 8th.	β Gruis . . .	... ... 52"1	... ... 55"2	... ... 60"1	89° 25' 56"55		
	Polaris . . .	... ... 57"2	... ... 56"6	... ... 52"2			
	α Gruis . . .	... ... 52"1	... ... 60"3	... ... 57"3	... ... 56"6		
	MEAN . .	27° 40' 53"9	89° 25' 59"1	89° 25' 54"1	9° 5' 56"6		

Azimuth of R. M. from h. s. = 269° 25' 56"6

Mean computed distances and Azimuths.

OBJECT.	DISTANCE.			Azimuth.
	Log feet.	Miles.		
To Mahadeo Pokra hill station from Peak XXIV .	5.2876466	36.729	25° 33' 42"	
" " XXV .	5.3117720	38.828	359° 43' 0"	
" " XXVI .	5.4535631	53.818	333° 24' 58"	
" " XXVII .	5.4419195	52.394	329° 3 22	
" " XXVIII .	5.5926676	74° 137	313° 22' 3	
" " XXX .	5.6428863	83.224	314° 59' 39	

Resulting co-ordinates for Mahadeo Pokra hill station.

Peak	XXIV	Computed from.		Latitude.		Longitude.		Height in feet.
		XXV	XXVI	27° 41' 31"80	85° 33' 47"56	27° 41' 31"5	85° 33' 47"1	
Peak	XXIV	27° 41' 31"80	85° 33' 47"56	7,109				
"	XXV	31°54	47°20	7,133				
"	XXVI	31°58	47°25	7,070				
"	XXVII	31°29	46°92	7,091				
"	XXVIII	31°08	46°50	7,072				
"	XXX	31°53	47°06	...				
	MEAN	27° 41' 31"5	85° 33' 47"1	7,095				

NOTE.—Height of Mahadeo Pokra hill station computed from Peak XXX is 7,009 feet. As this is so discordant it has been rejected.

Observed Latitude = 27° 40' 53"9.

Computed = 27° 41' 31"5.

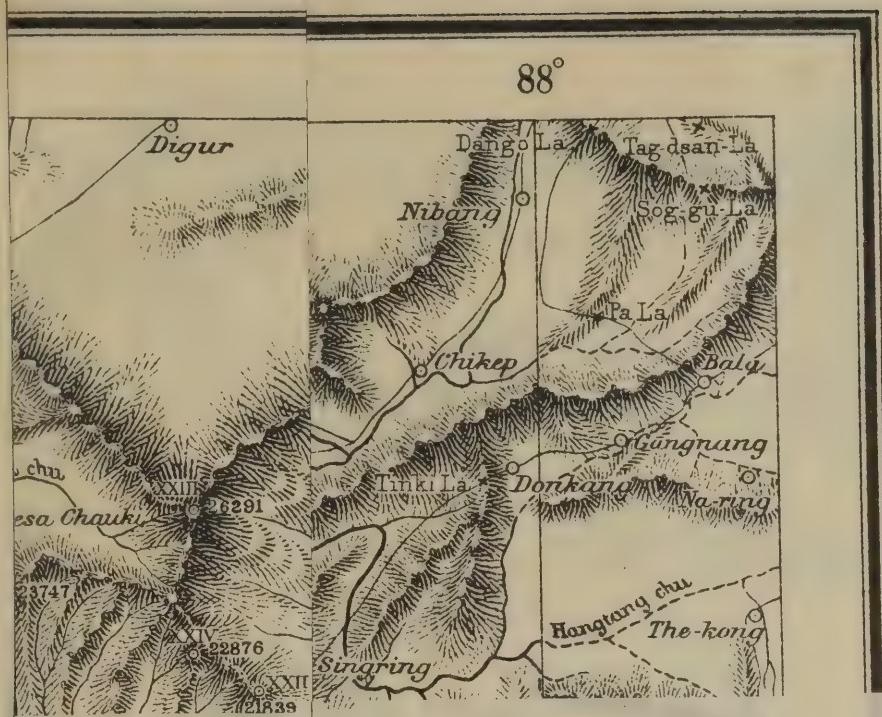
∴ O.-C. = -37"6.

Results of Identification of Snow Peaks.

Name of Peak.	Latitude.	Longitude.	AZIMUTH.		HEIGHT.	
			Computed.	Observed.	Computed.	Observed.
Peak XV	27° 59' 16"22	86° 58' 7"09	256° 21' 14	256° 20' 40	29,002	28,929
" XVII	27° 45' 15"54	86° 36' 58"10	265° 57' 22	265° 56' 43	22,820	22,763
" XVIII	27° 52' 50"52	86° 31' 58"62	257° 26' 20	257° 25' 26	21,980	21,933
" XIX	27° 58' 17"82	86° 28' 33"08	250° 46' 42	250° 45' 41	23,500	23,538
" XX	27° 57' 51"97	86° 22' 43"27	249° 13' 17	249° 13' 54	23,440	23,392
" XXI	27° 57' 28"83	86° 9' 8"85	242° 57' 16	242° 56' 38	19,550	19,477
" XXIII	28° 21' 6"74	85° 49' 21"76	199° 11' 18	199° 10' 50	26,290	26,339
" XXXIII	28° 29' 23"17	84° 13' 57"42	124° 22' 53	124° 21' 55	22,920	23,021
" XXXIV	28° 32' 4"99	84° 9' 52"78	124° 31' 51	124° 31' 46	26,040	...
" XXXV	28° 32' 11"32	84° 7' 32"33	123° 51' 56	123° 52' 56	24,690	24,835
" XXXVII	28° 29' 40"71	83° 59' 22"12	120° 17' 30	120° 17' 25	22,940	23,057
" XXXVIII	28° 29' 53"64	83° 59' 20"56	120° 22' 46	120° 22' 26	22,960	23,084
" XXXIX	28° 35' 44"31	83° 51' 46"52	121° 20' 52	121° 21' 2	26,492	26,563
" XL	28° 31' 5"21	83° 50' 55"72	118° 55' 31	118° 55' 33	23,607	23,770
" XLVII	28° 40' 20"10	83° 19' 7"02	116° 48' 23	116° 47' 54	23,539	23,766
" B 439	27° 57' 11"2	86° 25' 18"2	250° 55' 17	250° 54' 45	...	...
" B 522	28° 16' 20"3	85° 35' 48"9	182° 57' 19	182° 57' 12	22,010	22,148
" B 495	28° 10' 36"4	85° 5' 41"7	208° 36' 21	208° 36' 0	21,760	21,755
" B 484	28° 6' 14"6	85° 56' 35"7	219° 15' 22	219° 14' 55	19,740	19,901
" S 31	28° 10' 10"0	85° 43' 17"7	196° 23' 35	196° 23' 11	...	...
" Kaulia h. s.	27° 48' 58"6	85° 16' 47"9	116° 18' 54	116° 18' 28	7,031	7,034

part of

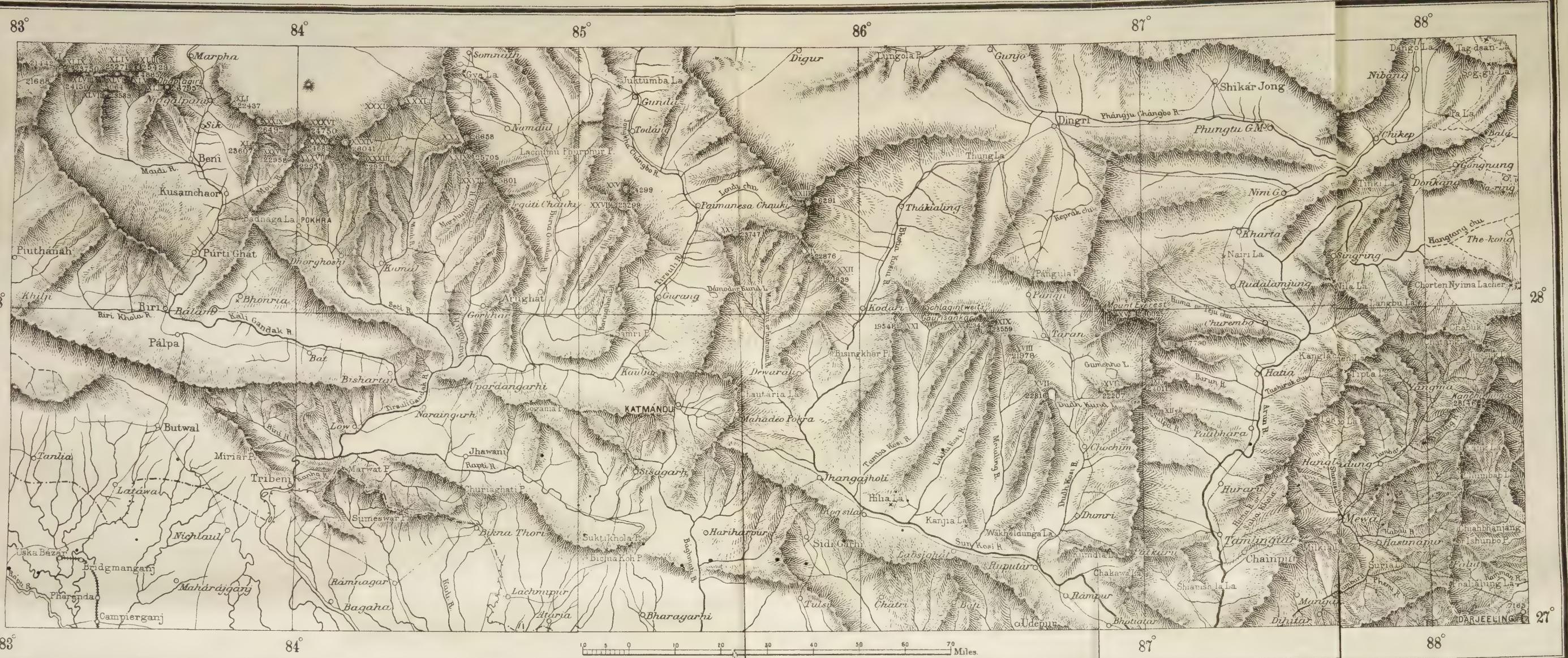
Inch = 16 Miles.



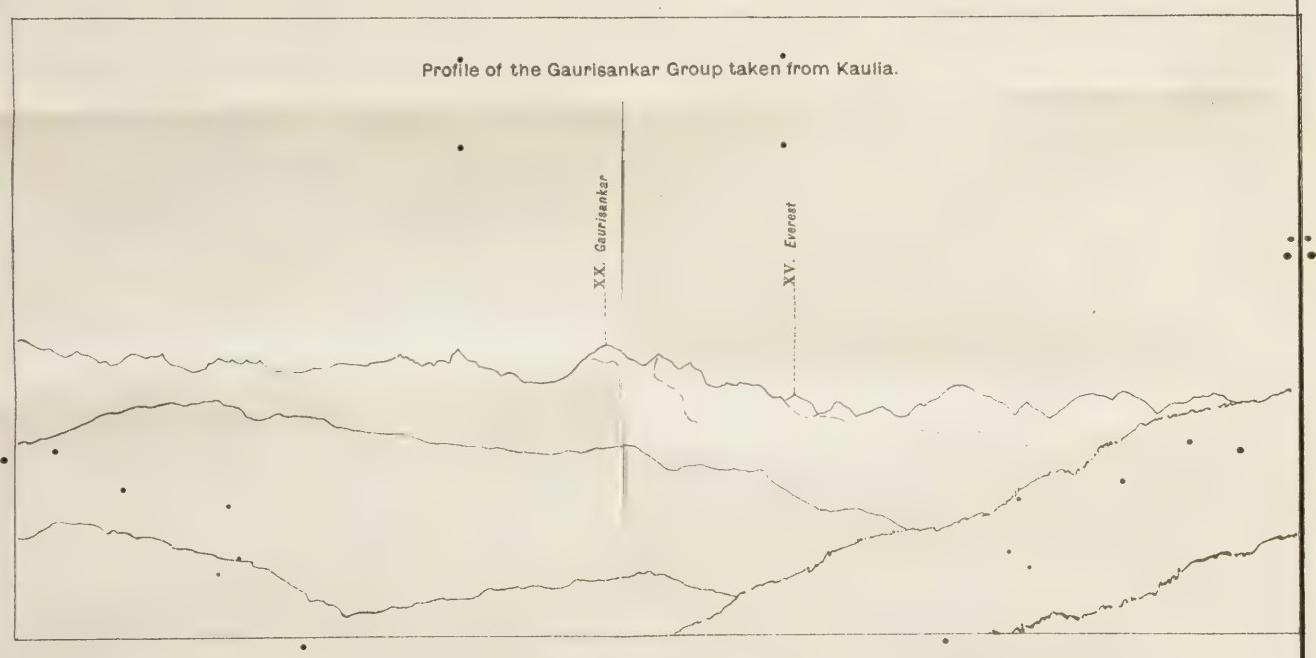
the survey
of India

Sketch map of part of Nepal

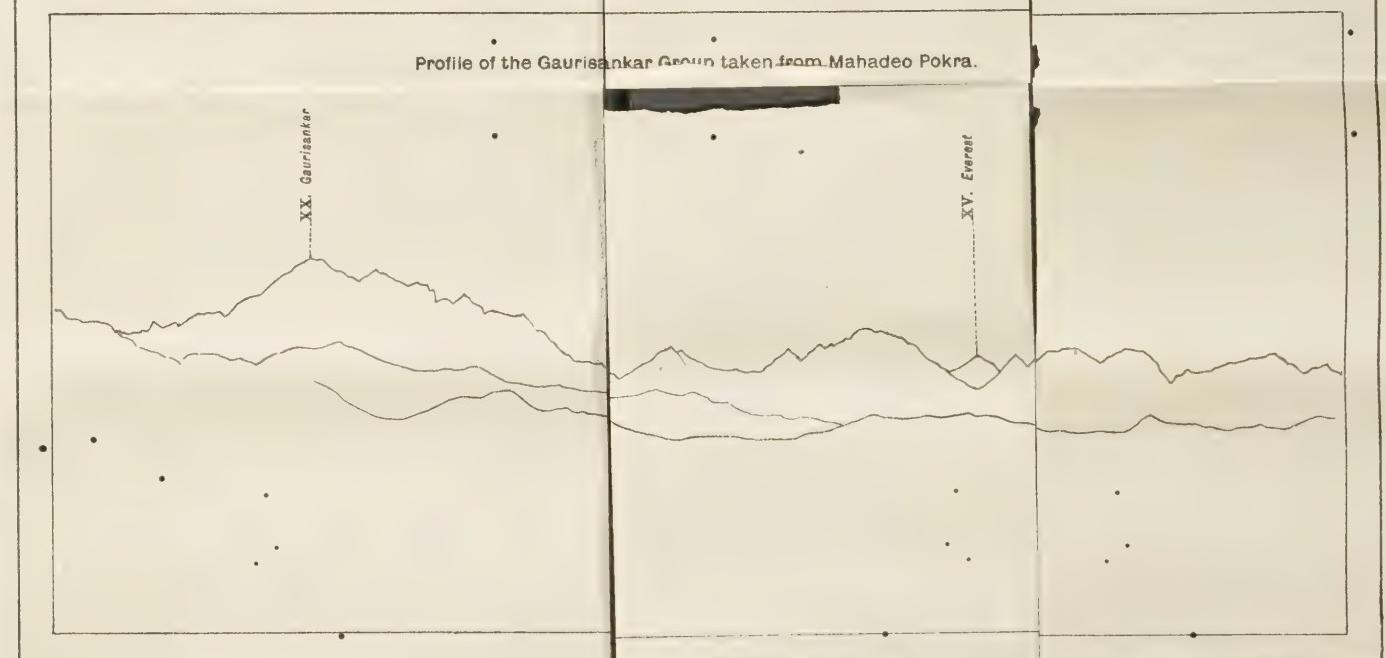
Scale 1 Inch = 16 Miles.



Profile of the Gaurisankar Group taken from Kaulia.



Profile of the Gaurisankar Group taken from Mahadeo Pokra.



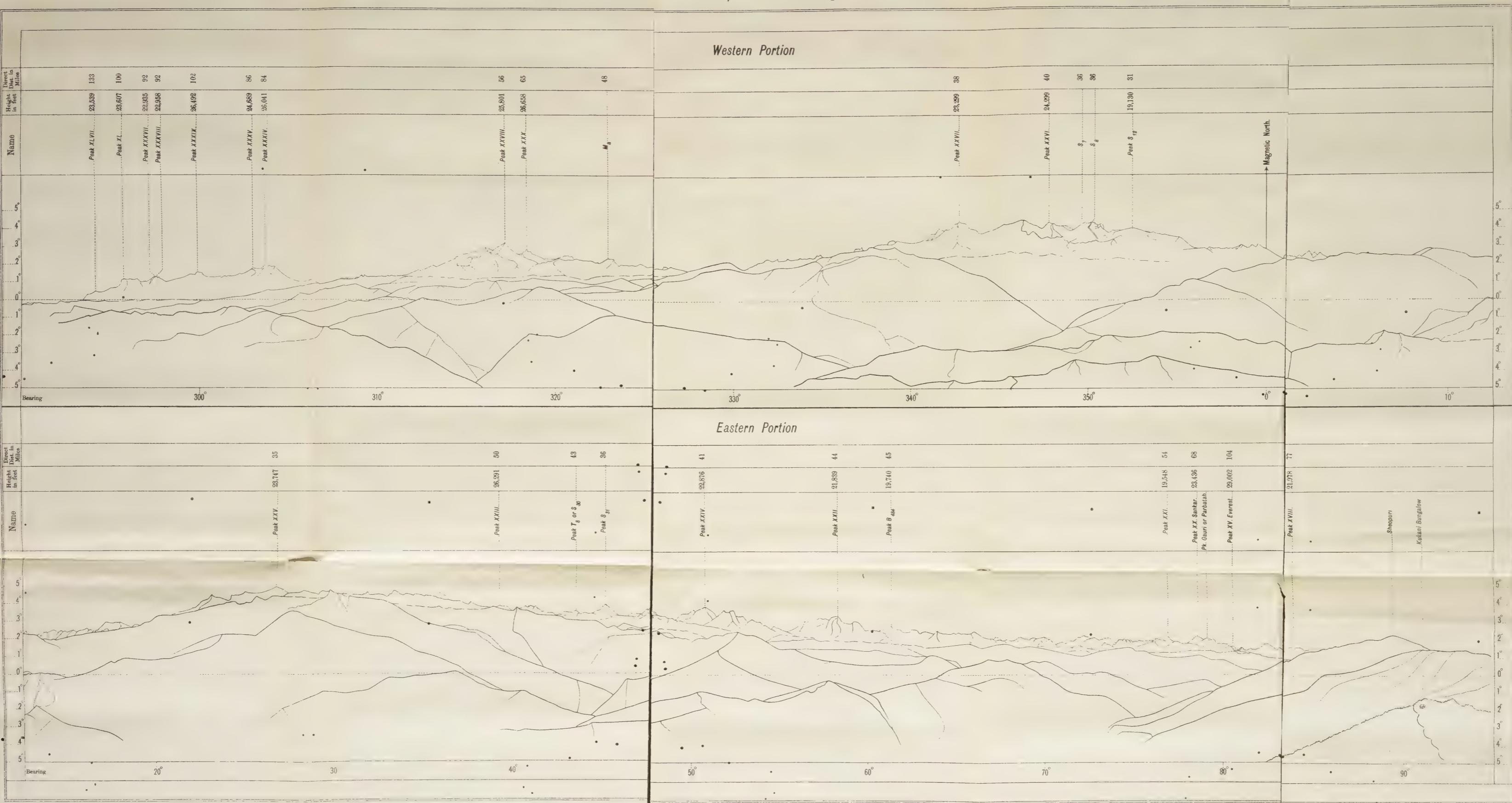
FILE

Kat

THE UNIVERSITY
OF ILLINOIS

PANORAMIC PROFILE OF THE HILL RANGES OF NEPAL

from Kaulia Hill near Katmandu, Lat: $27^{\circ}49'$ Long: $85^{\circ}17'$ Height 7,051 feet.



Haben untersucht at the Survey of India Office, Calcutta.

Published under the direction of Lieut. Colonel F. B. Longe, R.E., Surveyor General of India.
March 1904.

Price One Rupee.

No. 177, S. I - Apr. 04 - 420

Reg. No. 680-S. 04.

AMI
Pok

0.5000000000000001 0.5000000000000001

0.5000000000000001 0.5000000000000001

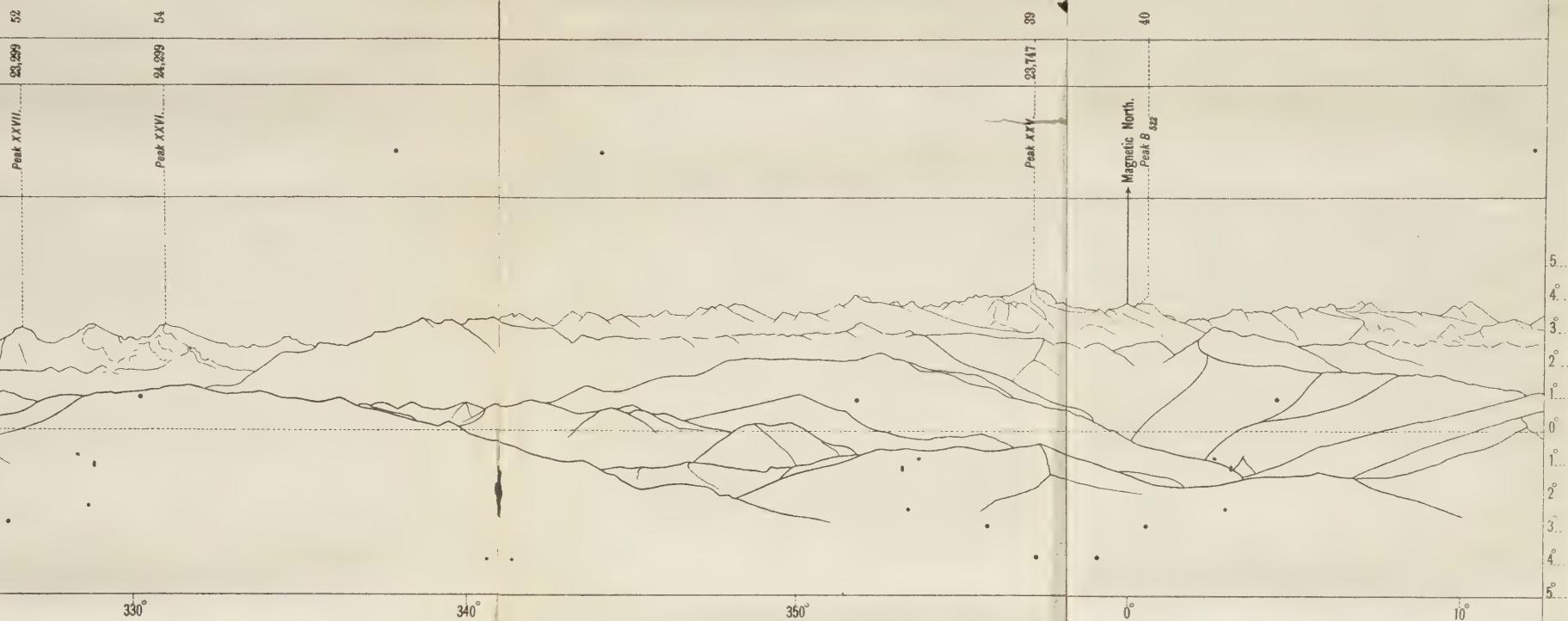
0.5000000000000001 0.5000000000000001

0.5000000000000001 0.5000000000000001

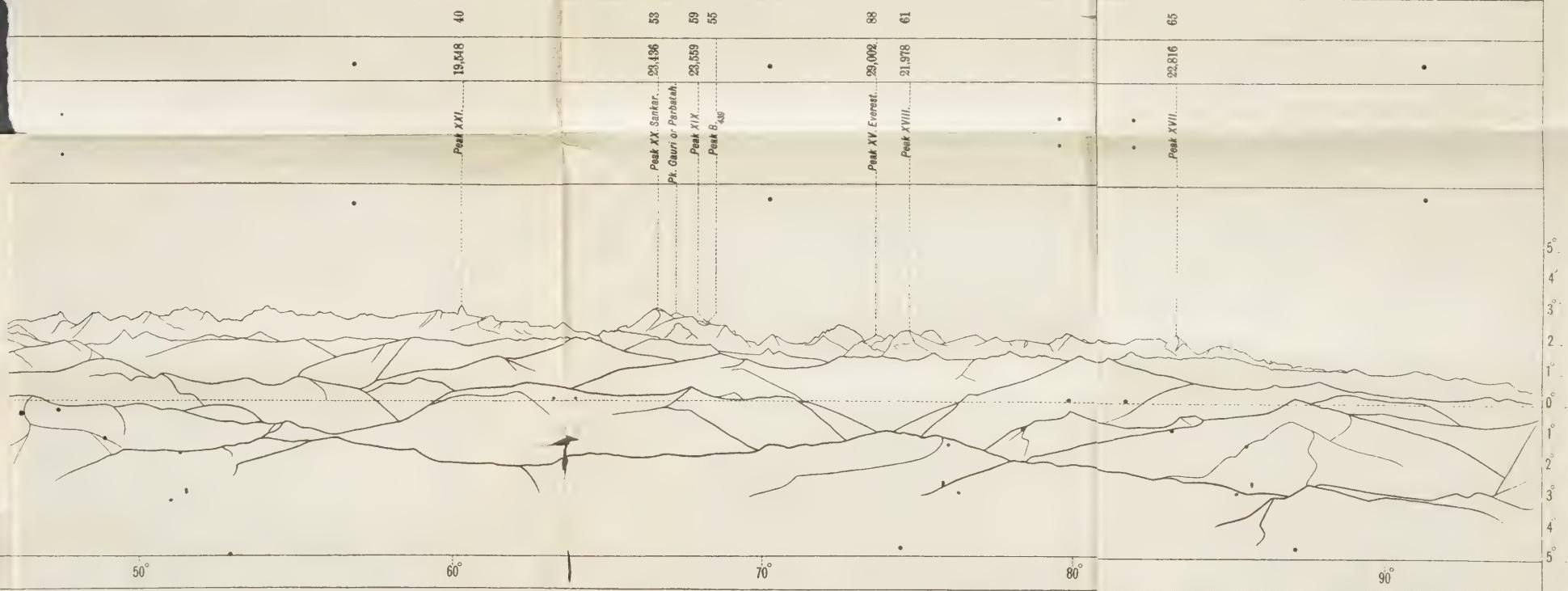
0.5000000000000001 0.5000000000000001

AMIPROFILE OF THE HILL RANGES OF NEPAL
PokHill near Katmandu, Lat: $27^{\circ} 42'$ Long: $85^{\circ} 34'$ Height 7,095 feet.

Western Portion



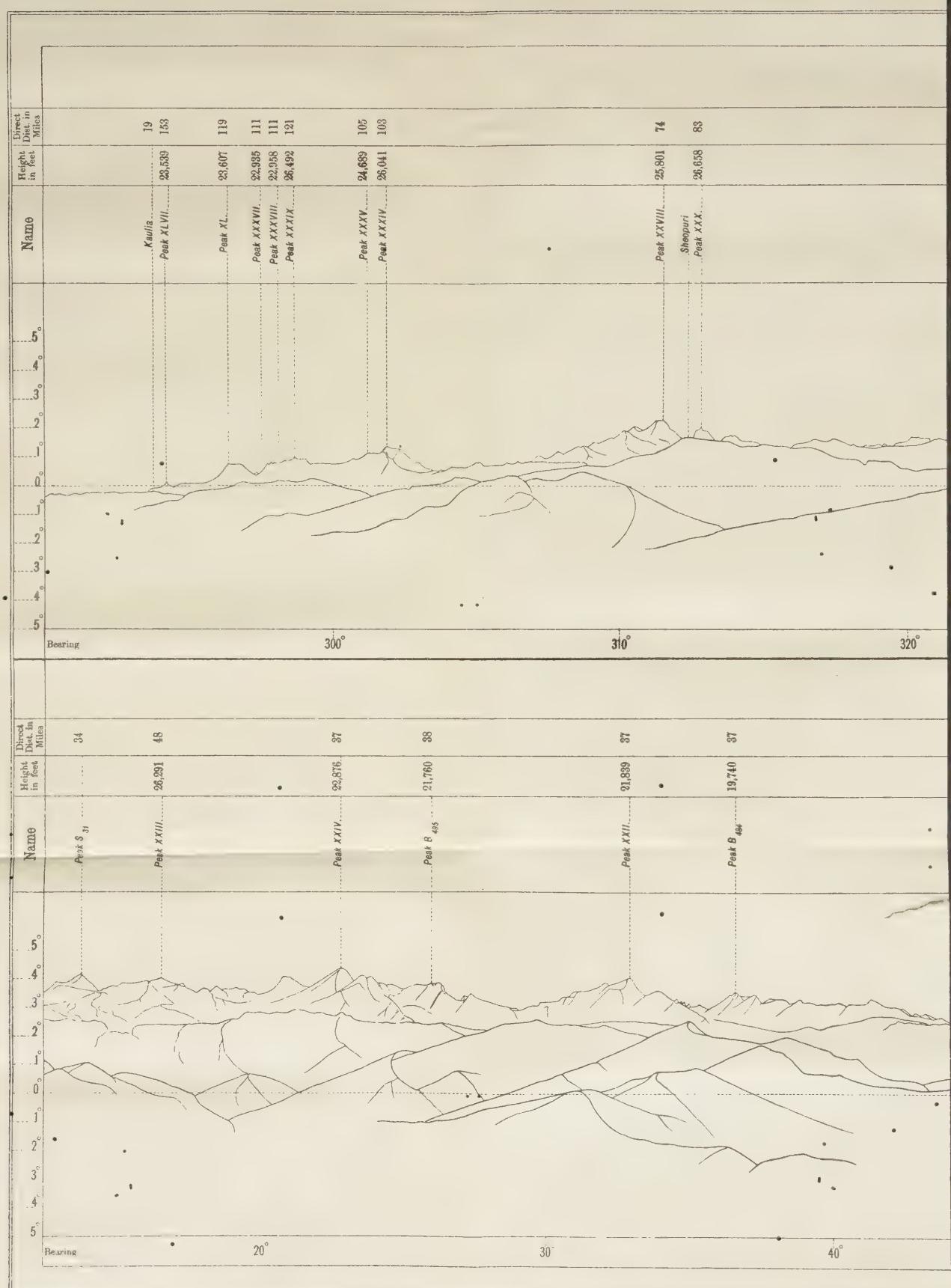
Eastern Portion



LEADER

88 88.39 108.38

PANORAMIC from Mahadeo



*Report on survey operations with the Tibet Frontier Commission by
Captain C. H. D. Ryder, R.E.*

On 24th September 1903, I received orders at Bangalore to join the Tibet Frontier Commission at Kam-pa Dzong. Proceeding via Calcutta where I had to spend a few days collecting instruments and kit, I arrived at Siliguri, the railway base on the 3rd October and marched out the same afternoon to Sevoke, where the Tista leaves the hills. This was not the time of year to see the Tista valley at its best, very hot, raining every day and all day, the march up the valley was far from pleasant. The cart road, now open as far as Gang-tok, was then constantly blocked by landslips and very slippery. After Gang-tok was passed the views of the snows should have been magnificent, but the higher hills were veiled in clouds, all the more pleasant, therefore, was the marked change once the frontier pass, the Kangra La, was crossed; clouds were left behind, and during the two months I stayed at Kam-pa Dzong we had nothing but the finest weather with that wonderful clear atmosphere which every traveller in Tibet has remarked on.

Down the long slope from the Kangra La and over the rolling downs near the village of Giri, the great snowy range gradually opened out, till on reaching Kam-pa Dzong, or at any rate from the hill above it, one continuous line of snows was visible stretching from Cho-mo-lha-ri to Mount Everest, a distance of some 150 miles. We were able to survey from this snowy range northwards to the Arun river—Tsang-po watershed; the Tibetans beyond sending men to watch us, but making no attempt to stop us surveying so long as we did not camp away from the mission post.

As regards the heights of peaks our results were of a negative nature. The highest point on the above named watershed was 20,100 feet; the two "very high snowy mountains" mentioned by Mr. Freshfield on page 362 of the R. G. S. Journal for March 1904 were disappointing, being only 21,200 feet in height. The fine snowy range apparently running north from Everest, but in reality running north, but some 30 miles east of Everest, has its highest summit at an elevation of 22,200 feet. In the photograph by Mr. Hayden (R. G. S. Journal, March 1904) it will be noticed that the northern side (*i.e.*, the right-hand one in the photograph) of Everest has a continuous slope which I estimated at 7,000 feet, and it is extremely unlikely that north of Everest and hidden by the nearer snowy range (on the right edge of the photograph), the peaks could again rise to a height anywhere approaching that of Everest. It is interesting here to note that Everest as viewed from Kam-pa Dzong, does not appear as the highest peak of a group, but as one massive summit standing by itself; nowhere could we hear of any local name for Everest although careful enquiries were made. The height of Kam-pa Dzong itself proved to be 15,200 feet, instead of 13,800 as on previous maps.

Fortunately, just as we had completed all possible surveying from Kam-pa Dzong, it was decided that the mission should retire and cross the Dzelap La into the Chumbi valley. We accordingly hurried across Sikkim, and caught up the main body of the mission and its escort at Chumbi. This valley is disappointing; it has always had a great reputation, but we found it to be only 200 or 300 yards wide, and not very rich. The houses at Rin-chen-gong are good, but this is due to the fact that the Tomos who inhabit the valley having a monopoly of the carrying trade from Phari Dzong down into Sikkim.

A short halt here enabled me to get the lower end of the valley surveyed, and detach Sub-surveyor Dalbir Rai, who followed the valley down to the plains and returned to Gnatong by the adjoining valley, thus completing a most useful piece of work including a hitherto unsurveyed portion of Bhutan.

The mission then moved up to Phari Dzong and over the Tang La (height 15,200 feet), a very easy pass, to Tü-na (height 14,800 feet). Here we spent the winter and except for some work in the Chumbi valley, surveying was nearly at a standstill; the Bhutan snowy range on the east, lower rounded hills on the west, and the Tibetan force at Gu-ru 6 miles north of us, limited our sphere of observation. The cold was intense, and a very unpleasant three months were spent before we again advanced. Numerous cases of pneumonia occurred, mostly fatal. Amongst them were two of my *khalasis*, but Sub-surveyor Hazrat Ali was fortunately one of the few that recovered. Towards the end of March Mr. Hayden, of the Geological Survey and I, with an escort of 20 rifles, made a short excursion across the plain to explore the Ling-shi La, a pass crossing the snowy range into Bhutan. Before, however, reaching this point we were met by a small Tibetan force and requested to return. In view of my knowledge that Colonel Younghusband was very anxious to avoid if possible a collision with the Tibetans, I decided to retire to Tü-na.

General Macdonald and the main force having arrived at Tü-na it was decided to make a preliminary advance to Gu-ru, where the Tibetans were encamped, and establish a post there. Our advance was opposed by the Tibetans who had divided their force, sending half to the east of the Bam Tso on the direct Lha-sa road. A short fight ensued in which the Tibetans suffered heavily. I left a surveyor with the post at Gu-ru, where he was able to do some work, while the main force returned that evening to Tü-na; on the 2nd April Captain Cowie, R.E. joined me, just in time for the advance to Gyang-tse which took place on the 4th April.

The Survey detachment was now constituted as follows :—

Captain C. H. D. Ryder, R.E., in charge.
 Captain H. McC. Cowie, R. E.
 Surveyor Sher Jang, Khan Bahadur.
 Sub-surveyor Dalbir Rai.
 Sub-surveyor Hazrat Ali.

Sher Jang remained in the Chumbi valley, the rest of the party accompanied the advance.

We camped on the 4th April at Gu-ru, and then marched round the shore of the Bam Tso to Chalu, and the following day did a short march down the narrow valley along which the stream flows connecting the Bam Tso with the Ka-la Tso. I ascended a point on the range between the two lakes from which a fine view of them was obtained. The Bam Tso has an area of about 25 square miles and the Ka-la Tso of about 15 square miles. Captain Cowie accompanied a mounted infantry patrol as far as Sa-ma-da ; they found the village occupied by Tibetans, were heavily fired on, and returned to camp in the evening. Next day the 7th April, we had a level march to Mangtsa, where the open country ends. We could see Sa-ma-da down the narrow valley ahead of us, but the Tibetan force had retired.

There is no outlet to the Ka-la Tso, but there are obvious signs that in ancient times the water flowed out of the lake into the narrow gorge to Gyang-tse and the Tsang-po. About 8 miles from the lake in this direction a small stream rises from what is probably an underground flow from the lake, and flows in a broad and deep bed down the gorge.

From Mang-tsa the force marched to 3 miles short of Kang-mar, while Captain Cowie and I ascended the range to the east to a height of about 18,000 feet to try and get a view ahead ; in this we were not successful, still higher hills on the north on both sides of the gorge blocking our view. The Tibetans were reported by the mounted infantry to be in force holding a wall across the valley at Kang-mar, but next day their position consisting of a strongly built wall, (which, however, could have been easily turned,) was found evacuated ; next day they were located in a position holding a narrow gorge, known as the Red Idol gorge, with precipitous hills on either side, they were easily turned out of this by a direct attack and a long flanking climb on the part of the Gurkhas. We camped at Sapu that evening and marched on to the Gyang-tse plain the following day. On the 11th April, the Dzong or fort of Gyang-tse was surrendered by the Tibetans who seemed cowed by the defeats they had received ; the mission was established in a village on the right bank of the Nyang Chu, where there is a bridge about 1,000 yards from the Dzong.

A force under Colonel Brander consisting of 2 companies 8th Gurkhas, 4 companies 32nd Pioneers, 2 7-prs., 2 machine guns, and 70 mounted infantry were left as escort, while the General and the main force retired to the Chumbi valley, leaving posts at Kang-mar, Ka-la Tso and other places on the line.

We now settled down to a peaceful existence, a bazaar was established outside the post and officers in small parties could wander about the plain shooting.

Captain Cowie and I were then able to start triangulation off a measured base, and with the help of three stations on the hills were able to complete all the work that was possible ; but we were not then able to connect this triangulation with Kam-pa Dzong and the Great Trigonometrical peaks, but we fixed some peaks on the Ka-ro La range which afterwards proved invaluable in connecting the Lha-sa triangulation with this work.

Towards the end of the month a report came in that a force of Tibetans had collected on the Ka-ro La, 45 miles from Gyang-tse on the road to Lha-sa. A party, consisting of 50 men of the 32nd Pioneers and 30 mounted infantry under Lieutenant Hodgson, was sent out to verify this report. As this would afford an opportunity of getting in a good addition to our map, I decided to accompany the party with Captain Cowie and Mr. Hayden.

We reached Ra-lung, two long marches from Gyang-tse, on the 29th April, and the following day accompanied by the mounted infantry, rode up to the pass, about 2 miles beyond, where we saw the wall which the Tibetans had built. Lieutenant Hodgson took a few men forward to draw their fire and make them disclose their strength. In this he was successful and withdrawing his men without loss, although some Tibetans concealed on the hills above were rolling rocks down on them, we rode back to Ra-lung. I had intended taking the mounted infantry to Kang-mar in one long day's march, as it was important to have this route reconnoitred, but owing to the presence of the Tibetans in such force on the Ka-ro La, this was not now considered advisable, and we returned to Gyang-tse in two marches, arriving there on the 2nd May.

Colonel Brander then decided to take out a force to turn the Tibetans out of their position on the Ka-ro La, as they were threatening our line of communications. On the 3rd May he accordingly started, Captain Cowie again accompanying, as I hoped he might be able to get the route from Ra-lung to Kang-mar done this time. They attacked the Tibetans on the 6th and drove them out of their position, but owing to our having in the meantime been attacked at Gyang-tse, Captain Cowie had to return with the force.

On the 4th, everything at Gyang-tse seemed peaceable, I had been out for a long day surveying on the hills to the south, and on my return heard of a report, originating from one of the patients in Captain Walton's civil hospital, that we were to be attacked next day. A small mounted infantry patrol went some miles down the Dong-tse road but

found nobody. The Tibetan force, however, was at Dong-tse itself, and leaving when the moon rose about 1 A.M., attacked us just after dawn. Their attack was a complete surprise, but once our men turned out, the Tibetans were easily driven off with heavy loss. If, however, the Tibetans had not given the alarm by shouting and firing their guns, we would have been in a rather awkward position. Another force of theirs had in the meantime occupied the Dzong, from whence they opened a heavy fire which to every one's surprise more than reached our post.

Colonel Brander's force returned on the 9th and as the Tibetans had been hard at work fortifying the Dzong, it was decided that it was impossible for us to attack it with success.

As it was obvious that surveying was out of the question, Captain Cowie and I volunteered for military duty and were appointed Assistant Field Engineer and Field Engineer, respectively, and were fully occupied in re-fortifying the post. The Tibetans never could make up their minds to really attack again, but most nights they used to make an attempt which usually ended in a lot of firing and nothing else. They, however, occupied a house only 450 yards from the post and opened a heavy fire from it. It was gallantly rushed by our men next morning and an outpost, called the Gurkha Post, was established there. The Tibetans also made a regular attempt to invest us by occupying the villages in our rear; they were driven out of several of these and on the 24th May re-inforcements arrived, consisting of 50 of the 32nd Pioneers and 80 Sappers under Captain Sheppard, R.E., and two other R. E. officers.

There being now plenty of R. E. Officers, Captain Cowie and I reverted to our legitimate duties. The Pa-la village which was threatening our post was captured on the 26th May, after a long day's fighting. Captain Cowie left on the 28th May to try and connect the triangulation round Gyang-tse with the Kam-pa Dzong and Sikkim work, but owing to constant cloudy weather he was unable to do so. I spent my time in computations, and in fortifying the Pa-la village, in charge of which I was placed, as I had volunteered to do any R. E. work under Captain Sheppard, R. E.

We thus passed a rather dull existence; the Tibetans made repeated night attacks on the two outposts, but their hearts always failed them; and though at first they were rather exciting and when the Dzong joined in, quite fine pyrotechnic displays, but towards the end they became monotonous. During this time Colonel Younghusband left for Chumbi, the post at Kang-mar being attacked as he was passing through, when the Tibetans were easily repulsed.

Towards the end of June the relief force under General Macdonald advanced from Chumbi. The day before reaching we heard that the Tibetans had occupied the Nye-ning monastery on the road. Colonel Brander, therefore, took out a small force on to the range overlooking the monastery and village from which one had a good view of the fight, which ended in the defeat of the Tibetans in spite of a stubborn resistance. General Macdonald then in a few days captured, first the Tse-chen monastery, which lay on a hill some 4 miles down the valley, and then, though delayed a few days by an insincere attempt on the part of the Tibetans to negotiate, the Dzong was captured on the 6th July, and we were at length free from the continual bombardment which lasted for two months.

Captain Cowie and Surveyor Sher Jang who had come up with the relief force, now rejoined me and on the 14th July we commenced our march to Lha-sa. Owing to the cloudy weather, rendering triangulation impossible, I thought it advisable, in case we could not afterwards connect Lha-sa and Gyang-tse by triangulation, to run a subtense bar traverse, this entailed Captain Cowie and I being on the road all day, starting with the advance guard and getting in in the evening. The weather too was very bad, heavy rain falling almost every day, effectually dispelling the prevailing notion that this part of Tibet is a rainless country.

The Ka-ro La (height 16,200 feet) was crossed on the 18th July, the bulk of the Tibetans holding the position bolting the night before from the wall in the valley, leaving their companions on the hills to their left to escape as best they could. They were easily driven out of their position by the 8th Gurkhas, who established a record in hill fighting-at high altitudes, the Tibetan position reaching an elevation of 18,500 feet, and their retreat leading across the face of a glacier.

The next day the force moved to Nan-gar-tse Dzong in sight of the Yam-drok Tso lake. The snow peak marked in former maps in the centre of the promontory round which the Yam-drok Tso makes an almost complete circle, is a myth. No hill there has permanent snow, though as their height is about 17,000 feet, there doubtless is often snow lying there when there is none at Nan-gar-tse Dzong or on the shore of the lake (height 14,350 feet). After a day's halt we marched to Yat-sik where the original outlet of the lake obviously existed. We then marched for two more days along the shores of the lake, which all along this part is never more than 2 or 3 miles wide and very often less.

We crossed the Kam-pa La (height 15,400 feet) on the 24th, an easy ascent from the lake side, but a very long drop down to the Tsang-po. Owing to the low elevation 11,550 feet, and Sarat Chandra Das' description, I thought that the valley would have been well wooded, this, however, was not so the hills were quite bare and no trees grew wild, though round every village there were fine groves. We moved on 6 miles down the river to the place selected for the crossing, where the Tibetans had kindly left a large ferry boat on our side of the river.

The whole force had crossed on the 30th, a very laborious process only marred by the death of Major Bretherton, Chief Supply and Transport Officer, who was drowned by the upsetting of a Berthon boat raft. The valley here is broad and well cultivated, the river running in most places in several broad channels with sandy islands in between. It was about at its highest flood level soon after we had all crossed, with a very fast current deep, and about 140 yards in width.

On the 31st July we moved on, and after a few miles turned up the Kyi Chu, a well cultivated valley with a broad shallow river, resembling the Tsang-po valley on a slightly smaller scale. On the 2nd August we arrived at the To-long Chu, a large affluent of the Kyi Chu, and over which there is quite a good bridge. From here we were rewarded by our first sight of the Potala, the residence of the Dalai Lama, situated on a small isolated hill overlooking Lha-sa. Next day camp was moved to within a mile of the Potala; this was, however, only a temporary camp, and being swampy, another site was selected on drier ground north of the town, the mission being located in a very good house in pretty wooded grounds outside the town.

The weather was not favourable for surveying, rain fell constantly and heavy clouds lay on the surrounding hills, so after measuring a base, and observing a latitude and azimuth we confined ourselves to the survey of the town and suburbs of Lha-sa on the scale of 6 inches to the mile. This took some time, as we were at first not allowed to enter the town itself; but later on, having got in all the somewhat extensive groves, gardens, and summer residences outside the town, we were allowed to march through the streets with an escort. In order to avoid attracting attention, for this portion of the work we did not use a plane-table, but made a compass and pace traverse from one fixed point outside through to another fixed point on the other side. The inhabitants showed some curiosity but no hostility at our proceedings. The height of the plain above sea-level is 11,830 feet.

Captain Cowie left Lha-sa on the 29th August to return to Gyang-tse, to try and secure the connection in the triangulation between that town and the points I had fixed from Kam-pa Dzong. The weather now began to improve and I was able to go out with a small escort, firstly up the valley a day's march from whence I took mounted infantry up to the junction of the Pen-bo Chu with the main valley, just opposite the Ga-den monastery and some 30 miles from Lha-sa and secondly up the Tö-long Chu, a somewhat similar expedition.

Having done these two trips there only remained the Pen-bo La, the pass on the main road leading north and about 10 miles from Lha-sa. This was important for the triangulation, and I was lucky to do all that was necessary in a short spell of fine weather, which just coincided with the five days I spent in camp at the foot of the pass, climbing a hill of 18,000 feet elevation each day. From this range we were able to sketch in carefully the adjoining valley to the north, a broad well cultivated and thickly populated plain; and from three stations I was able to connect on with the peaks of the Ka-ro La range and also to fix many points north and eastwards, including some fine snow peaks south of the Tengri Nur, mentioned by Mr. Littledale, the highest of which was 23,250 feet in height, the highest we ever came across north of the Tsang-po. Two other snow peaks which I fixed are, I believe, those mentioned by M. Bonvalot and christened by him Mount Huc and Mount Gabet, but their heights were disappointing, the highest being 21,500 feet.

The treaty was formally signed at the Potala on the 7th September, and on the 23rd we left on our return march, re-crossing the Tsang-po ten miles above the point where we originally crossed, and then ascending the range between it and the Yam-drok Tso by the Do La, 16,000 feet, a long steep climb from the river. From this pass, the weather being clear, I had a fine view and was able to fix a station by observation to peaks on the Ka-ro La range and to two Bhutan peaks, already fixed from India, as well as to one of my stations on the hills north of Lha-sa. I had gone on ahead of the main force with an escort of 100 Gurkhas under Major Row. Next day we marched along the lake to Yar-sik, and ascended the range again, and observing from two more stations, the required connection between the triangulation done from Gyang-tse and that done at Lha-sa was secured.

At Yar-sik on the 30th September we met Captain Cowie, who though much hampered by the cloudy weather had effected a satisfactory connection between the Gyang-tse triangulation and the Kam-pa Dzong work, we here struck off the main route up the side valley, across a very low, in fact almost inappreciable watershed, and followed down the narrow valley known lower down as the Rong Chu, which flows into the Tsang-po. I have no doubt whatever that this is the old outlet of the Yam-drok Tso which now is land locked. Next day we left the valley, camping near the Nya-dong La, (height 16,000 feet) crossed the pass next day and so on to the plain above Ra-lung. This survey was useful in that it shewed the possibility of turning the Ka-ro La. Captain Cowie then made a round from Ra-lung into the Ni-ru valley down to Gob-shi and so to Gyang-tse, while I caught up the main force. I now made arrangements for Captain Cowie to complete the remaining work between Gyang-tse and Chumbi, on which he writes as follows:—

"On the 8th October with Sub-surveyor Hazrat Ali and a portion of the survey detachment I left Gyang-tse for Kang-mar, which was reached next day. Commencing a route survey from this village on the 10th, we struck off the

line of communications, marching eastwards through a narrow defile in the bare-rocky hills dividing the waters of the Nyang-Chu and the Ni-ru Chu, as far as the Nilung La, which we crossed the same day, we followed the track which is part of the main road from Kang-mar to Ra-lung *via* the Wogya-la. After crossing this pass and descending into the open plain which receives the head waters of the Ni-ru Chu, we turned southwards, heading for the Bam Tso. Passing over the low rolling hills which intervened, we reached the lake on the 14th October, completing the survey of this locality and fixing the position of the Yu Tso, a lake lying at the foot of the snowfields of the big range, culminating further to the south-west in Cho-mo-lha-ri. On the 14th I got into communication with the head-quarter staff which had just reached Ka-la Tso, and, for the purpose of adding to the $\frac{1}{2}$ -inch survey of the Kam-bu valley, obtained sanction to strike off the line of communications at Tü-na and crossing a pass some 12 miles west of the Tang La, to follow the course of the Kam-bu Chu, eventually rejoining the force at Chumbi.

Surveyor Sher Jang, who had accompanied the force from Gyang-tse as far as Ka-la Tso, joined me at Cha-lu on the 14th. On the 16th we left Tü-na, taking with us from there, a Tibetan who professed to know the hills to the east of Powhunri, and camped in a small valley below the pass.

On the evening of the 16th snow began to fall and by the 17th, and 18th, a severe blizzard had set in. We left camp on the 17th, in the midst of it, purposing to cross over into the Kham-bu valley, but were unable to reach even the pass. In consequence of mist and the thick driving snow it was impossible to see more than a few yards in any direction : we had no track to guide us and the snow was nowhere less than two feet deep. The difficulties of progressing were great and in addition, we, the guide included, lost our way. Though only a few of the party were frost-bitten, many had begun to suffer from snow blindness. Finding it impossible to proceed, with much trouble, we eventually got back on the 18th, to a point near our camping ground of the 16th. Next day, with over 50 per cent of the party incapable from snow blindness, we crossed the Tang-La and reached Pha-ri in the evening. On the 22nd, I reached Chumbi and reported to the General Officer Commanding (the telegraph line having been broken by the storm), who had sent out a search party for us from Chumbi.

The whole had recovered from snow blindness and the effects of exposure sufficiently to move on the 26th to Chumbi which we left on the 28th, and marching *via* the Nathu La and Gang-tok, reached Siliguri on the 5th November."

The survey results of the expedition are as follows :—

Triangulation.—An area of 45,000 square miles was completed connecting Lha-sa with India, all prominent peaks which were visible, with their heights, being fixed.

Topography.—An area of 17,000 square miles was surveyed on the scale of 4 miles to the inch, of which 3,000 square miles in the neighbourhood of the Chumbi valley, Gyang-tse and Lha-sa, were surveyed on the scale of 2 miles to the inch.

Route surveys on the scale of 1 inch to the mile were made of the road to Lha-sa. Large scale plans were also made of the towns of Gyang-tse and Lha-sa.

Captain H. McC. Cowie, R.E., was of great assistance to me throughout, he is full of energy, and a very good draftsman.

Surveyor Sher Jang, Khan Bahadur, is a most careful and accurate plane-tableer, always turning out excellent work, at my request he was "mentioned in despatches."

Sub-surveyor Dalbir Rai did an excellent piece of work in Bhutan.

Sub-surveyor Hazrat Ali was with me throughout the expedition, he is an honest worker, and has improved greatly in his plane-tabling.

Report on survey operations on the journey from Gyang-tse to Simla via Gar-tok by Captain C. H. D. RYDER, R.E.

When the treaty was signed at Lha-sa on the 7th September 1904, it was decided that a party should proceed to Gar-tok to examine the place, as it was one of the trade marts which the Lha-sa Government had decided should be opened in Tibet. It was obvious that this would afford a great opportunity of adding to our geographical knowledge of the country ; accordingly with the approval of the Surveyor General, a strong survey party accompanied the expedition. The ostensible object of the journey being a political outcome of the treaty, Captain Rawling of the Somersetshire Light Infantry, the officer deputed to open the trade mart, was placed in general control of the expedition with instructions to conform to my wishes in regard to survey matters. He was assisted by Lieutenant Bailey, 32nd Pioneers, whose knowledge of the Tibetan language proved very useful, the survey party consisting besides myself, of Captain H. Wood, R.E., and Sub-surveyor Ram Singh, R.S. Three military surveyors also accompanied us ; one of these went sick and had to be sent back from Pin-dzo-ling, and very little use could be made of the other two owing to their limited knowledge of surveying, and to the fact that we were strong enough without them to carry on the work.

In making our arrangements for the journey, two considerations were paramount; firstly that we would be having a race against winter, with a possibility in the event of our being unable to get over the passes into India before the winter snows fell, the unpleasant prospect would have to be faced of having to winter at Gar-tok or some equally cold and inhospitable spot; secondly it was quite impossible to tell whether and to what extent, the Tibetans would assist us. Fighting had only lately ceased, the treaty had been signed barely a month previously, and there had been no opportunity of seeing whether the Tibetans would adhere to the treaty when our troops were withdrawn to India.

Our time for preparation was very short, every day's delay increasing the probability of our being snowed up. Captain Wood and Lieutenant Bailey arrived at Gyang-tse, which was to be our starting point, on the 30th September, while Captain Rawling and I only reached the same place on the 6th and 5th October, respectively.

Our transport we organised as follows:—Twenty-six baggage ponies to give us a nucleus of our own, should the Tibetans make difficulties about providing us with animals; 17 riding ponies, it being important that, in view of long and continuous marching at a high elevation, as many men as possible should be mounted; 100 yaks were lent to us from one of the Transport Yak Corps to take us to Shi-ga-tse, but not to go beyond that town. From there onwards, however, the Tibetans invariably and without any demur provided us with whatever transport we required. Ponies, donkeys, mules, yaks and coolies at various times carried our baggage, and although it was difficult to supervise so large and mixed a caravan, no single article was lost during the whole time the journey lasted.

We took two months' supplies for all our men, with two months' extra of such things as ghi, goor, etc., which could not be obtained *en route*; while for the officers' mess we took four months stores. Meat we could rely on obtaining in abundance, and *tsamba* or parched barley flour, as long as we came across villages.

Our party was finally organised and ready to start on the 9th October as follows:—

- Captain C. G. Rawling, Somersetshire Light Infantry.
- Captain C. H. D. Ryder, R.E., Survey of India.
- Captain H. Wood, R.E., do. do.
- Lieut. F. M. Bailey, 32nd Pioneers.
- Sub-surveyor Ram Singh, R.S.
- Hospital Assistant Hira Singh.
- 3 Military surveyors.
- 5 Sepoys of the 8th Gurkha Rifles.
- 5 Survey *khalasis*.
- 7 Pony drivers.
- 2 Hindustani servants.
- 2 Tibetan servants.

Mahomed Isa, a Ladakhi, who acted as caravan leader, and last but not least, a very small Lhasa Blenheim spaniel who followed our fortunes throughout.

In order to have the advantage of the company of Captain O'Connor, who was remaining as trade agent at Gyang-tse, and who with two other officers was making a trip to Shi-ga-tse, we postponed our departure till the 10th.

Our first day's march took us to Dong-tse, the late head-quarters and supply dépôt of the Tibetan army, which had attacked the mission and its escort for two long months at Gyang-tse, but here, like everywhere else, we were cordially received, mainly I fancy owing to our being accompanied by a Lha-sa official who had been deputed to escort us to Gar-tok, and also to our being supplied with a very strongly worded permit signed with the seals of the Lha-sa Government and of the three great Lha-sa monasteries, and directing all officials along the route to render every assistance.

Three more marches, following the valley of the Nyang-Chu, which is one of the richest and most prosperous valleys of Tibet, landed us at Shi-ga-tse on the 14th October. Here we spent several busy days with an army of tailors making warm clothing for ourselves and our men, lining all coats with lambskins, making fur caps and gloves, etc., till finally when fitted out we all presented an appearance akin to Arctic explorers. Our stay at Shi-ga-tse was not, however, all work. We paid a most interesting visit to the great Tra-shi Lhun-po monastery, where the monks received us most cordially, shewing us all over the place, and finally giving us refreshments of tea, cakes and dried fruits. This monastery is said to contain 4,000 monks, and although not so large as, is richer than, the great Lha-sa monasteries. The bulk of the buildings, the residences of the monks, were of the usual type, narrow paved roads with high houses on each side, dirty and not picturesque, but we all enjoyed the sight of the tombs of the five previous Tra-shi Lamas each a separate building with its golden roof, and highly ornamented interior, fitted with a wealth of turquoises, gold bowls, and rare old jade and cloisonné, the effect being somewhat marred by a foreground of small vessels holding lighted tapers, fed by very evil smelling butter. Bogle's description of his visit is very picturesque and accurate, the number of tombs has now, however, increased from three, as seen by him, to five as seen by us.

We were fortunate also in being received by the Tra-shi Lama, who, after holding an almost co-equal position to the Dalai Lama has now by the deposition of the latter, become the most important ecclesiastic in Tibet. He was living in his summer residence, a house outside the town to which, with Captain O'Connor as Political officer at our head, we pro-

ceeded. A little hitch occurred at the gateway, as an arch scoundrel Colonel Ma, who had been the Chinese official at Gyang-tse, when we were attacked, and had never given us warning nor even tried to protect the servants and property of his colleague Captain Parr, was also paying a visit. Captain O'Connor refused to enter the house while this individual was in it, and the latter had to be smuggled out by some back door; we were then shown up some steps and along dark passages till we arrived at the reception room, at the far end of which we could see the Tra-shi Lama seated cross-legged on cushions on a raised platform. He received us each with a bow and a smile which we returned and were shown to seats on one side of the room while the other side was filled with Tibetan officials and monks in either the ordinary maroon coloured clothes usually worn by monks, or in the yellow silk of the higher temporal officers. Tea, undrinkable as usual, was handed round, but on this occasion it had a certain glamour attached, due to its being served in enormous teapots of gold and silver. Dishes laden with sweetmeats and dried fruits were also brought in, and soon hurriedly removed and handed over to our followers.

While Captain O'Connor was exchanging civilities with the Tra-shi Lama we had time to think of the sudden change from a few months before, when the Tibetans, amongst whom was a strong contingent from this very place Shi-ga-tse, were attacking us at Gyang-tse, to the present moment, when we, a few unarmed officers were sitting in amity with our quondam enemies. The Tra-shi Lama himself is an interesting personality, sixth holder of the office, his face is one that would not pass unnoticed anywhere, still less in Tibet. He has clear cut features, high cheekbones, and a pale complexion; his quiet dignified manner made a lasting impression on us. His age is only about 23, and he seemed generally beloved and revered. During the whole of our visit a slight and pleasant smile never left his face. After silk scarves had been presented to us and our Tibetan followers had been blessed, we left, with the feeling, due partly to the personality of the Lama himself, partly to the room with its dim light, that we had been assisting at some religious ceremony.

We had commenced our survey at Dong-tse one march from Gyang-tse and as we wished to keep up triangulation, Captain Wood and I left Shi-ga-tse on the 17th October to do two short marches, the rest of the party leaving a day later and doing the two marches in one. Owing to bad weather, which gave us some rain and covered the surrounding hills with snow, we were unable to reach our hill, so decided to halt a day at Kang-jen Gom-pa, a most delightful camp in a grove of trees. This was the same storm which entailed such hardships on our force returning to India in the neighbourhood of Pha-ri Dzong; fortunately for us we were here at the lowest point of our journey, the height of Shi-ga-tse being 12,570 feet, and escaped with only slight inconvenience. By visiting three hills, one of which was over 18,500 feet elevation, and from two of which we had fine views of Mount Everest, Captain Wood was enabled to carry on the triangulation under very adverse circumstances. To climb one of these hills is itself a hard piece of work, to observe at the top in a bitter wind is one of the most physically painful operations I have ever experienced, and to do this in combination with a day's march, leads to a very long and hard day's work. Captain Wood carried this on for days and months with hardly any intermission, a feat which could only have been accomplished by an officer of his energy and determination.

Until we reached Pin-dzo-ling on the 22nd October the river had been a few miles to the north of our route, but from thence we followed the river more closely. Two more marches and we were at Lha-tse Dzong, a fort on a small rocky hill, very similar to those at Shi-ga-tse and Gyang-tse, surrounded on one side by the river, and on the others by a fair sized monastery and small town. The valley here widens out into a plain, cultivated in parts, barren elsewhere. At Lha-tse Dzong, we halted a day, which enabled Captain Wood and me to ascend a hill a few miles east of the town overlooking a broad bare valley which leads to the very famous Sa-kya monastery. We regretted that want of time, and the consideration that it was not advisable to divide into two parties until we had thoroughly tested the friendly disposition of the Tibetans, had prevented us from paying a visit to this monastery.

From Lha-tse however, the Tibetans having shewn no desire but to assist us in every way, we decided to separate; while Captain Wood and Lieutenant Bailey followed the main route which here crosses and leaves the river, Captain Rawling and I stuck to a route reported to lead along the south bank, as I did not wish, if possible, to omit any portion of the river from our survey.

Accordingly, on the 26th we parted company, camping that night on opposite sides of the valley which now closed in, we kept to the river the following day, but on the 28th we had to leave it and for two marches followed up a side stream, the Chi Chu, running parallel to and only two or three miles distant from the Tsang-po, which we again rejoined on the 30th. On the 1st November, we could see that the river flowed between rocky hills with snow peaks on either side, compelling us to leave it. Making a wide detour to the south we marched up a side nullah, camping in bitter cold at nearly 16,000 feet, and crossing the Kura La, a very desolate pass, next day at an elevation of 17,900 feet, marching across the head of a plain, which forms the head waters of the Chi Chu, previously mentioned, we passed over an almost imperceptible watershed down a narrow stony valley to the village of Ka-jü. We had a magnificent view from a hill a few hundred feet above the pass of the main Himalayan range. Mount Everest stood up towering above the rest of the range in its neighbourhood, in one isolated peak a continuous drop of some 8,000 feet separating it from the rest of the range east and west of it. The village of Ka-jü (14,800 feet) lies

on the edge of the Su-tso-tang plain, which takes its name from an old ruined fort on a small eminence in its centre. It is here about five miles wide and we could see it trending away southwards and joining the Dingri maidan which lies north of Mount Everest. A day's halt here enabled me to cross this plain, from the hills on the western side of which I obtained an uninterrupted view of Mount Everest, no hills intervening. I was thus able to satisfactorily establish the fact, which I had suspected a year before at Kam-pa Dzong, that no peaks anywhere approaching the height of Everest exist to the north of it or anywhere in its neighbourhood; it stands alone in its magnificent solitude and is entirely disconnected from the mass to the west, of which peak XX (Gaurisankar) is the best known point, on the south-east of Everest but separated from it by a low gap lies Peak XII (Makalu). We were here in the valley of the western branch of the Arun or Kosi river, but recrossing the watershed next day by the Sheru La 17,600 feet, we once more reached the banks of the Tsang-po on the 5th November. The scenery was now changing, trees we had said goodbye to some marches back, our last cultivation we passed that day, while the hills were becoming more open and the plains abounded in sand dunes. Brushwood was in places available for fuel, but we preferred argol or dried yak dung as it gave greater heat, and, if the fire was carefully looked after, less smoke. During the whole of this portion of the river journey, we had seen no four-footed game other than numerous hares and a few gazelle on the Su-tso-tang plain, but birds we saw and shot numbers of; Tibetan partridge, ram chikor, and Tibetan sand grouse giving us a welcome change in our otherwise monotonous fare of mutton.

On the 6th we crossed to the north bank of the river with the utmost difficulty, a crazy looking punt manned by lamas took us across in detachments, but owing to the masses of floating ice whirled down the river by the rapid current, the punt was repeatedly forced back, and only reached the opposite shore after floating down some 400 yards; the operation of hauling the boat up again to its original starting point against the ice being very hard work. On the 9th we arrived at Sa-ka Dzong a small village, and found that Captain Wood's party had reached there the day previous. We gave ourselves another day's halt here as there was a good deal of surveying to be done in the neighbourhood.

Captain Wood writes as follows regarding his journey:—

"Leaving Lha-tse on the 26th October we crossed the Tsang-po about half a mile below the town. A couple of boats had been collected by the Tibetans for ferrying across our kit and transport, but the process was very much shortened by the discovery of a ford about $\frac{1}{4}$ mile up stream, by which the ponies were able to cross. After keeping to the north bank for about 10 miles, we turned up a side nullah, and camped at Sang-ge-lung village; following this nullah next day for a short distance, we crossed by an easy pass into a country, the drainage of which led into a succession of small lakes, whose surfaces were covered with geese and duck. On the largest of these the Ngap-ring Tso, a ta-sam or stage house is situated, which place we reached on the 27th, and hearing that no grain would be procurable until we reached Barkha on the Manasarowar lake, we bought all we could procure, but even this would only give our ponies a couple of pounds daily. The next day we passed Ralung the last place we saw cultivation. Every day now found us at a higher altitude as we were marching more or less along the watershed between the Tsang-po and its large tributary the Ra-ga Tsang-po. The valley of this latter stream is narrow, running almost due east and west, parallel to and about 30 miles to the north of the main river. Into this distance is crammed a tangled mass of hills whose crests average about 18,500 feet, with several peaks of about 22,000 feet covered with permanent snow. This part of our march was exceptionally unpleasant, as the wind on the hills never dropped by day below hurricane force, and camping at elevations up to 16,100 feet, the change in temperature from the comparatively warm valley of the Tsang-po, was most noticeable. The hills clothed with a coarse grass on their lower slopes, but quite bare above 17,000 feet, were as a rule easy to climb, and from the summits lovely views of the Himalayas were obtained. Makalu and Everest, both standing out as great isolated peaks, being particu'larly imposing. The ta-sams at which every four or five days we changed our yaks for fresh ones, were the only signs of habitations we encountered, and these as a rule consisted of tents with a mud hut or two. The marches were all long, and wearisome in their monotony, and owing to the narrowness of the valley, Ram Singh and I had to climb to the crests of the range every day, to carry on the survey, seldom getting into camp before sunset, and on one or two occasions not arriving before nine or ten at night. On the 5th November, we crossed the Ku La (16,700 feet), situated at the head waters of the Ra-ga Tsang-po, and by a steep descent dropped into the valley of a small stream draining into the Tsang-po. At that night's camp we received letters from Captain Ryder saying that he would arrive at Sa-Ka Dzong on the 9th. Passing under the snowy range of Cho-ur Dzong, whose peaks range up to 21,000 feet, we reached Sa-Ka Dzong on the 7th November".

During our halt at Sa-Ka Dzong, Captain Wood ascended a high peak to the north (19,300 feet), from which we had a fine view north, up the valley of the Charta Tsang-po, a tributary of the main river.

Sa-Ka Dzong (height 15,150 feet) has only a dozen or so houses, very dirty, the neighbourhood being like that of every Tibetan village, a dust and refuse heap. We left on the 11th November, again in two parties; this time Lieutenant Bailey accompanied me back to the river, while Captains Rawling and Wood followed the main route. That day

we forded the Char-ta Tsang-po, a fair sized affluent of the main river, and crossing some low hills, reached the Tsang-po on the 12th, which we crossed late on the same evening, it being necessary to do so then, as from my previous experience, I knew that the river would be nearly impossible in the morning from floating ice. We crossed in a small skin boat, our animals fording higher up. For several days we marched up stream in a broad valley covered with low sand dunes and stones, with a very small quantity of poor looking grass on which, however, kyang and gazelle seemed to thrive. The track followed by the Pandit Nain Singh, as he marched up from Nepal to Tra-dom in 1865, joined in on our left, but in these plains in Tibet, it is difficult to find any signs of a path, as every caravan meanders over the plain without keeping to any defined track.

We recrossed the river on the 16th, but now it was completely frozen over; a good track was made for the animals by throwing some earth down on the ice. That evening we reached Tra-dom, where we found the rest of the party had arrived on the 14th. The weather had taken a turn for the worse; low temperatures at night with cold winds in the day were the rule, but if the days were sunny, a little walking would soon make us warm; when the days were cloudy, however, there was nothing to counteract the cold, and a march was a most miserable performance.

Captain Wood writes:—"On leaving Sa-Ka Dzong our party kept down the valley till we reached the Char-ta Tsang-po, which we found no difficulty in crossing. The stream was at that time some 100 feet in width with a depth of two feet flowing in one channel, having just left a very deep narrow valley to emerge into a plain of about 3 miles in width. Striking up a small side nullah we followed it for 5 miles and camped at the foot of the La-lung La. On this pass we first saw signs of ovis ammon, and from the information we received, this appears to be the eastern limit of their habitat along the road we had traversed. The road for the next three days, if it can be called a road, was the worst we met with, and consisted of large broken rocks set in deep sand; and to make us even more uncomfortable, the weather changed to snow accompanied as usual by a howling gale of wind. In hospitable as Tra-dom appeared to us when we first described it, we hurried on as fast as our ponies would take us, to get within the shelter of its single stone house, where we might warm our frozen limbs over a yak dung fire, and pity the remainder of our party who had still another two days to endure before they could hope to join us."

Tra-dom did not tempt us to halt, it is a desolate spot, with a small monastery on the hill above, inhabited by only 3 or 4 monks; but from the hills to the north, we had a fine view of a snowy range reaching an elevation of 23,200 feet. We accordingly left the next day, and marching across the plain all day, camped amongst the hills on the far side. This plain is full of small ponds lying among sand dunes, and there was an unpleasant tributary or two to cross, the water frozen at the edge for four or five yards, then a drop of 3 feet into icy cold water full of floating ice, ending with a scramble out on the other side on to ice again. We now followed the river valley for a week or so, always in the same large plains, until we could see the watershed range ahead of us from the valleys of which innumerable streams issue to form the Tsang-po, the largest coming from a snowy range to the south-west. After enjoying some days of bright sunshine, the weather again took a turn for the worse, and we crossed the Ma-yum La, (height 16,900 feet) on the 26th November with a foot or two of snow on the ground. We had now finished with the Tsang-po, having surveyed it from Shi-ga-tse to its source. Our next point of interest was to be the lake region ahead of us. The day after crossing the Ma-yum La we camped on the northern shore of the Gün-chu Tso, a lake 11 miles long by 2 or 3 miles broad, with an area of 22 square miles, completely frozen over, and having no outlet at all. Several ovis Hodgsonii (ammon) had been shot before reaching the Ma-yum La, and we now came on large herds of Tibetan antelope, of which we each shot several, and could have shot many more if we had wished, as they were very tame. Crossing several low passes and generally undulating ground we came in sight of the Manasarowar lake (Tibetan Tso Mo-bang) on the 30th November. The lake is neither impressive nor beautiful, like say, the Yam-drok Tso passed on the way to Lha-sa. It was not frozen over, except for 100 yards or so round the edge. The water was fresh, and our Surveyor Ram Singh, on account of its sanctity, bottled some and carried it back with him to his home in Dehra Dún. Skirting the lake, we rode across the low hills which close in on the western side, to look for the outlet, which Moorcroft had not been able to find, which Strachey had found, and which Mr. Savage Landor had claimed to have discovered did not exist. We struck the channel a mile below the outlet, a small stream only partly frozen over, this we followed up and found that it did not flow from the lake but from a hot spring, at which we found and shot some mallard. We then followed up the dry nullah to the lake, and proved that Strachey was, as was to be expected quite correct. No water was flowing at this time of year, but the local Tibetans all agreed that for 4 months in each year there was a flow during the rainy season and the melting of the snows, i.e., about from June to September. As a rise of about 2 feet in the level of the lake would cause water to flow down the channel, this appears quite worthy of belief. The length of the channel between the two lakes is about 3 miles. That day, the 2nd December, we reached a Tibetan stage house, and next day had a long days ride to try and discover an outlet for the second lake, the Rakas Tal or Tibetan La-gang-Tso. This lake is very dissimilar to Manasarowar in shape, and was entirely frozen over. The latter is about the same width 12 miles north and south as it is east and west, with

an area of 110 square miles ; the former is a long narrow lake running north and south, some 16 miles long by 3 or 4 miles wide, with an area of about 55 square miles.

It is the sacred character of the Manasarowar lake rather than its size which has made it well known ; its height above sea-level is 14,900 feet. We found an old stream bed issuing from the Rakas Tal, but every Tibetan we asked told the same story, that no water ever flowed along it now, but in days gone by, one man saying before the Sikh War, water did flow out of the lake and down this channel. We followed it down for some 6 miles along the plain, and could find none of the ordinary signs of water flowing down it, until we reached some low hills ; here, evidently from the lie of the sand, water flowed at some time of the year and away from the lake. The lakes being now entirely disconnected at all times of the year from the Sutlej, the sources of that river must lie in the hills on either side of the valley and west of the lake region.

The Kailas snow peak was very prominent on the hills to the north, 21,800 feet in height. The strata forming the mountain are horizontal, which gives it a peculiar appearance ; from the side we saw it, the top was quite inaccessible. There are several monasteries on the path which pilgrims follow in circumambulating the mountain. A very fine snow mass culminating in a peak over 25,000 in height, Me-mo or Gur-la Mandhata, lies to the south of the Manasarowar lake. A low watershed south-west of the lake leads to Purang or Taklakot.

Keeping to the north side of the broad open valley in which the Sutlej flows we arrived at another stage, Men-ze or Missar on 5th December. Here we divided sending our heavy baggage down with Ram Singh, as I wanted him to continue the survey of the Sutlej valley, while we went into Gar-tok. We were pleasantly surprised to find the Jer-ko La, the pass on the Sutlej-Indus watershed low and easy (height 16,200), and without difficulty reached Gar-tok (height 15,100 feet) on the 9th. This is the summer residence, Gar-yarsa. The two Gar-poms, the joint governors of western Tibet were residing at Ger-gunsa, the winter residence, some 30 miles down the valley, but had come up to receive us.

We only halted one day at Gar-tok, in that time we had seen more than enough of it ; we were unanimous in looking on it as one of the most dreary inhabited places we had struck in our journey ; a long broad plain, absolutely bare, with a dozen wretched hovels in the middle, constitutes, at this time of year, what is in summer the chief trading centre of western Tibet ; but in the summer, traders are said to collect in large numbers, living in tents. The wind howled round the hut we were in continuously, and the weather looking threatening, we were not anxious to stay a minute longer than was necessary for Captain Rawling to settle up trade questions with the Gar-poms. Having now accomplished the main object of our journey, it only remained for us to get back into India as soon as possible. Fortune had favoured us so far but we had some high passes to cross. The first of these was the Ayi La, height 18,700 feet ; two marches took us to the top of the pass, encountering a blizzard the second day. That evening we saw the only herd of wild yak we had come across in our journey. Crossing the pass next day was no easy matter, the ascent was gradual, but there was 2 feet of snow on the ground and a bitterly cold wind was blowing. It was with the utmost difficulty that, under some shelter from a rock, I took boiling point observations, and with a sigh of relief hurried down the other side. One of our chief obstacles was surmounted. It began snowing on the pass that evening so we had only just crossed in the nick of time, at Dun-kar (14,100 feet) where we camped that night we met cultivation for the first time, and it was a pleasant feeling, we were gradually coming to the end of high altitudes.

From here Captain Rawling and Lieutenant Bailey next day marched to Totling (Tibetan Tü-ling) on the Sutlej, where they met Ram Sing's party. Captain Wood and I halted a day at Dun-kar and marched next day to Ti-bu, where the whole party was once more united. We were now in the most intricate country I have ever seen, it must resemble the loess formation of Western China. The bottom of every nullah was some hundreds of feet below the general level of the valley, with their edges so cut and worn into fantastic shapes that it was difficult to believe that one was not looking on the ruins of old castles. There are also innumerable caves in which the inhabitants live.

On the 16th December at Kyi-ni-puk, we met Thakur Jai Chand who had been sent up as our trade agent at Gar-tok ; he brought with him some very welcome newspapers. I must own we none of us envied him his job for the winter.

Each day's march now consisted of climbing up out of a deep nullah and down again into the next. We crossed the Shi-ring La 16,400 feet on the 21st in deep snow with great difficulty, the descent on the western side being very bad going. Next day we camped at Tyak on the Sutlej, which had been flowing to the left of our route only a few miles distant, but invisible to us owing to its being at the bottom of a deep gorge. On the 23rd we marched to Shipki, crossing the river on the ice at an elevation of 9,300 feet. On Christmas Eve we surmounted our last obstacle, the Shipki La on the frontier, a climb of 5,000 feet mostly in snow and a drop of 6,000 feet on the other side, camping at Kha in British territory. From here we had 18 marches into Simla, finding bungalows at every stage, on and after 28th December, finally arriving at Simla on the 11th January.

I am indebted to Captain Rawling for the unfailing readiness with which he fell in with my proposals regarding the survey work, and for the excellent transport arrangements he made *en route*. Lieutenant Bailey's knowledge of the language was of the greatest assistance in obtaining for us the correct spelling of names and other information.

Captain Wood, as I have already mentioned, carried out the triangulation in a wonderful way. No one who has not experienced it knows the determination necessary to stay on a hill top in the bitter cold, and the pain involved in touching the screws of a theodolite.

Sub-surveyor Ram Singh is a first rate trans-frontier surveyor, and added one more to the list of expeditions on which he has done excellent work.

Hospital Assistant Hira Singh, not only doctored our party and brought us through without the loss of a man, but created an excellent effect by the care and patience he displayed in attending to the many Tibetans who came in to be treated.

The area surveyed with the plane-table comes to about 40,000 square miles, comprising the valley of the Tsang-po from Shi-ga-tse to its source, and the Manasarowar lake region, the doubtful points connected with which have been the subject of much discussion were satisfactorily decided. We completed the survey of the Sutlej river from its source to where it enters British territory, as well as the source of the Gar-tok branch of the Indus.

The triangulation, which is still under computation, was invaluable in correcting the plane-table work, and determining heights.

An account of the Scientific work of the Survey of India, and a comparison of its progress with that of Foreign Surveys by Lieutenant-Colonel S. G. Burrara, F.R.S., R.E.

The scientific work of the Survey of India consists of—

- Principal Triangulation
- Levelling Operations
- Astronomical Operations
- Pendulum Operations
- Tidal Operations
- Magnetic Survey
- Solar Photography.

I beg that I may show in a few brief notes the uses and aims of the scientific work of the survey, but before doing so I wish to premise that no distinction can properly be drawn between scientific and practical work. Many operations conducted on scientific principles have immediate practical uses: they may in fact be likened to the exploitation of visible outcrops of coal. Others are more experimental, and may be likened to borings for invisible coal, believed to exist at certain depths. Others again are speculative, and may be likened to deeper borings, made to ascertain the strata in the crust, with the hope, that something valuable, perhaps coal or iron or gold, may turn up. But whether such operations are practical or experimental or speculative, they all have the same twofold purpose, *viz.*, the acquisition of information, and the rendering of that information useful. Almost all the the scientific operations of the Survey of India will be found to fall into the first category, and to possess immediate practical uses.

Before I enter into the details of the different scientific operations of the Survey of India, I may perhaps be allowed to refer briefly to the general question of the connection between science and surveys in modern times.

The primary object of a national survey is the making of maps, and all operations are subordinated to that end. It is for topographical purposes that a national survey measures its allotted portion of the earth's surface. If, however, these measurements be subsequently combined with astronomical determinations, the size and shape of the earth can be deduced, and a knowledge of this size and shape is essential to astronomers, geographers, geologists and meteorologists, all of whom look to surveys for information.

The great accuracy of modern astronomical observations for stellar and lunar parallax, and the difficulty, which mathematicians still experience in predicting exactly the places of the moon and the planets, are constantly necessitating more refined determinations of the figure of the earth, and astronomy is continually bringing pressure to bear upon surveys to lend her their aid,—for her celestial measurements must always emanate from a terrestrial base.

Man's first conception of the earth's figure was a plane: Greek philosophers thought it a sphere: Sir Isaac Newton showed that it must be a spheroid. Colonel Clarke, of the Ordnance Survey, contended that it was a triaxial ellipsoid. Modern Geodesy, after encountering great difficulties in testing in the field the theories of Newton and Clarke, has pronounced it a geoid. Astronomy now wishes us to tell her the dimensions of this geoid, and its departures from a spheroid.*

In the days of Everest the figure of the earth was deduced from linear measurements, and the Great Arc of India was the only series of triangulation in India originally designed for a figural determination: all our other triangulation was intended and executed for the purpose of controlling topography. In 1858, Colonel Clarke showed that the figure and dimensions of the earth could be better deduced from measured areas than from measured arcs, and the whole triangulation of India became at once available for the discussion, provided it were subjected to astronomical tests.

* A small portion only, however, of the earth's surface has so far been surveyed; and our present idea of the dimensions of our planet has been derived from wide generalisations. The total area of land and sea amounts to nearly 200 millions of square miles: the areas that have been surveyed do not aggregate 6 millions of square miles.

* The geoid is the figure enclosed by the surface of the sea: this surface is that of a spheroid disfigured by protuberances and hollows.

The determination of the figure, and of the dimensions and of the specific gravity of the geoid is now in the hands of an International Geodetic Association, at whose conferences Professor George Darwin, F. R. S., represents Great Britain: India's co-operation is the more valued by the association, because she alone of the civilized nations possesses an equatorial area, and because she includes within her dominions the highest points of the earth's surface.

The amount of money spent annually by Europe and America on astronomical observations, runs into many millions sterling: humanity is striving to discover new facts concerning the myriads of distant bodies moving in space. As her development progresses, she grows ever more desirous too of investigating the one celestial body, which she can touch, and on which she finds herself travelling amongst the stars.

The difficulties, however, of studying even our own earth are great, because we are tied to its surface: our meteorologists cannot ascend into the atmosphere, our geologists cannot penetrate into the interior. We have learnt that the globe of rock, which constitutes our inter-planetary home, is the source of two great forces, gravity and magnetism; and a knowledge of the actions of these forces has become of importance to almost every branch of science. Their actions we have discovered are strangely dissimilar, and vary both with time and place.

The civilized nations are now making gravimetric and magnetic surveys of the earth, and are measuring the intensities, the directions and the pulsations of the terrestrial forces. India has been asked to bear her share, and to carry these operations over her own fraction of land-surface.

THE PRINCIPAL TRIANGULATION OF INDIA.

Its Accuracy.

The principal triangulation of India has been repeatedly attacked on the grounds that it is too accurate and too scientific for practical purposes. In 1800, in 1824, in 1850 and in 1886, attacks were made, but the Government after enquiry ordered its continuance. The present seems a good opportunity to take stock, to see what the triangulation has done for us and what it has cost us, and to consider by the light of modern requirements its accuracy and its errors.

The operations of a survey may be conveniently divided into, (1) the controlling framework, (2) the artistic superstructure. In discussing errors and accuracy it is advisable to keep these two divisions distinct, for whilst the controlling framework has to be guarded against cumulative errors, the artistic superstructure is only liable to accidental or local errors. The framework is constructed as follows:—

Foundation	Principal Triangulation.
Plinth	Secondary Triangulation.
Walls	Tertiary Triangulation and Traversing.

Points fixed by tertiary triangulation or traverse should be sufficiently numerous to save the topographer from cumulative errors. Tertiary triangulation and traverses themselves, are liable only to accumulate errors over the short distances between secondary stations. In secondary triangulation the accumulation of error is confined to the distance which separates stations of the principal triangulation. In all survey operations, therefore, after the principal triangulation the accumulation of error is arrested: but what arrests the accumulation of error in the principal triangulation itself? The answer is that observations of a principal triangulation must be sufficiently accurate in themselves to avoid embarrassing accumulations of error.

We have been accustomed to state the error of triangulation in so many inches or so many feet per mile, and this custom has led laymen to believe, that the errors of principal triangulation are dispersed throughout its length. But the statement that an error has been found of 1 foot in a mile, is merely made to enable the merit of the triangulation to be gauged: in a length of 500 miles an error generated of a foot a mile is not dispersed, but is accumulated at the terminal. It follows, therefore, that the *requisite* precision of a principal triangulation must vary with the *distance* to be triangulated.*

The following table shows the relative degrees of accuracy in the triangulations of different countries: the precision and length of the triangulation of Great Britain have been taken as the units.

Country.	Precision of triangulation.†	Length of triangulation.	Ratio of precision to length.
Russia	2'0	3'3	0'6
India	2'2	3'0	0'7
Great Britain	1'0	1'0	1'0
Austria	2'0	1'4	1'4
Italy	2'0	1'25	1'6
Spain	2'2	1'2	1'8
France (modern)	3'0	1'2	2'5
Prussia (modern)	3'6	1'4	2'6

* The weight of triangulation varies inversely with its distance. The error of mean square increases with $\sqrt{distance}$, but in practice the terminal accumulation over a great length appears to be generally more due to systematic than to accidental errors.

† General Ferrero's report to the International Conference at Stuttgart in 1898.

The triangulations of South Africa and the United States are equal in precision to those of France and Prussia.

So long as a country is isolated, its survey will not concern itself with errors accumulated at its frontiers; a country like Prussia whose triangulation meets other triangulations on all sides, has experienced troubles that India has never felt. But India is losing her insularity and though the loss may be slow it is certain. Fifteen years ago the Indian frontier topographers began to experience embarrassments, because the longitudes of Indian mapping were $2\frac{1}{2}$ miles in error. It was futile to tell them, that an error of $2\frac{1}{2}$ miles in 6,000 miles was a small matter; the error was not dispersed over the 6,000 miles between Greenwich and India: it came in between our Indian and Afghan topography. The frontier surveyors suggested that each meridian should be drawn in two places on all Indian maps, and they subsequently proposed to project trans-frontier maps in terms of Europe instead of in terms of India, thus transferring the $2\frac{1}{2}$ -mile gap from their front to their rear. It was the topographical surveyor and not the scientific branch, that was experiencing the trouble. The incident teaches that an error of $2\frac{1}{2}$ miles may remain unnoticed during a century of insularity, but that at the first appearance of a small scale trans-frontier survey it begins to cause embarrassment.

The accuracy of European surveys gradually increased throughout the nineteenth century, and the difficulties of adjusting the discrepancies between contiguous triangulations became ever correspondingly greater. Eventually it was agreed to create a permanent court of arbitration, and the International Geodetic Association, to which all civilised nations now belong, was called into being.

Its Errors.

The triangulation of India has been controlled by base-lines: its errors of length do not, therefore, need consideration.* But base-lines exercise no control on direction, and if our astronomical results are to be believed, the triangulation has exhibited a constant tendency to deviate from the true course. Between Karachi and Calcutta an error in azimuth of $11''$ has been generated, and this has increased to $15''$ at Mandalay: our trigonometrical points in Eastern Burma have consequently been all displaced some 400 feet too far south. Between Cape Comorin and Peshawar an azimuthal error of $12''$ has been generated, and the relative orientation of these two places is 200 feet in error in consequence.

But the chief errors in the framework of Indian mapping are due not to faults in its construction, but to its location on the globe. Owing to errors in the original observations of longitude the Indian area has been placed on the globe $2\frac{1}{2}$ miles too far east: owing to obstacles placed by nature in the way of correct determinations of latitude in Central India, the Indian area has been located some 600 feet too far north on the globe.

Owing mainly to the deformation of the geoid in India, Everest's figure of the earth, on which all our calculations of latitudes and longitudes are based, has been given a diameter too small by 2 miles; the result is that our maps, though correct in their detail, have all been given too large a share of the earth's surface: our distance from Peshawar to Cape Comorin has been accurately measured, but we have given it in our maps 11 seconds more of latitude than it has a right to: our distance from Karachi to Mandalay has been made to embrace 17 seconds more of longitude than it is entitled to. At present we have no neighbours complaining of these overlaps, and the time has not come for us to trouble about them: it would in fact be premature for us to adopt a new figure, when great earth measurements are now in progress in Africa and America, and it would be premature for us to attempt a new location of India on that figure, until our pendulum and astronomical work has been extended.

If we sum up the errors in position accumulated on our frontiers, they are as follows:—

Peshawar has been placed too far north in latitude by 400 feet owing to figural errors, and by 600 feet more owing to errors of location on the globe: it is thus shown on our maps 1,000 feet too far north. Peshawar is, moreover, shown $2\frac{1}{2}$ miles too far east of Greenwich.

The Salween has been placed in longitude 1,100 feet too far east owing to figural errors, and $2\frac{1}{2}$ miles too far east owing to errors of initial longitude: it is thus shown on our maps $2\frac{3}{4}$ miles too far east. The Salween is shown some 300 feet too far north, the effects of the initial latitudinal error and of the accumulated azimuthal error being opposite in East Burma.

It is difficult to define numerically the meaning of an "embarrassing accumulation of error," because as a survey matures it begins to feel the pinch of errors, which it failed to notice in its youth. Any accumulation of error is embarrassing, that obliges surveyors to recalculate their data. Changes in data due to revisions of computations, even when such revisions are based upon important new observations, cause great inconvenience, and decrease the value of the data for co-ordination purposes.

In dealing with problems connected with the determination of the figure of the earth no inconvenience arises from using revised data, and it is relatively easy to make revisions, as comparatively few points are concerned.

When triangulation is being used for controlling maps and co-ordinating surveys, the aim of adjustment is to avoid purely local distortions; but when it is being employed to

* In the 747 miles separating Karachi and Attock the error in length accumulated in the triangulation, and eliminated by the measurement of the Attock Base-line, was 99 feet.

investigate the form of the geoid, it is of importance only to have correct relations between very distant points. In discussing then the meaning of "embarrassing accumulations of error," we have only to consider the geographic purposes of triangulation, and we can dismiss from our minds the geodetic.

There is no doubt that the error of $2\frac{1}{2}$ miles in longitude has already become embarrassing to India: our $\frac{1}{1,000,000}$ maps have different longitudes to our 1-mile maps, and our 4-mile maps have longitudes differing from the other two, and these discrepancies must be inconvenient to the great body of map-users, who are not in the secret of the longitude footnotes. The longitude error is in fact so large that it will probably, in the future, necessitate a revision of data: and if such a revision comes to be carried out, the opportunity will doubtless be taken to eliminate also our figural and latitudinal and azimuthal errors.

As to the error of 1,000 feet in the latitude of the triangulation at Peshawar, this accumulation causes at present no inconvenience: but if our triangulation ever comes to be connected with Russia's, the overlap in latitude will amount to half a mile or more, because Russia is projecting her triangulation on too small a spheroid, just as we are doing. The two surveys will then have different values of latitude for every boundary pillar; it is impossible to foresee now what course they will agree to take: but if we may judge from examples in Europe, they will refer to the International Association, and they will perhaps be advised to correct their data.

Its cost.

In a Parliamentary paper published in 1851, Sir A. Waugh estimated the cost of the principal triangulation at Rupees 7-2-5 per square mile. If the same work were to be executed now, it would probably cost double. Since the estimate was prepared, triangulation has been carried over Rájputána, Sind and the Punjab, at a cost averaging 15 Rupees per square mile. The average original cost of the whole principal triangulation of India may be estimated to have been about 9 Rupees per square mile. This cost applies to the area actually triangulated, and not to the total area controlled.

In 1798, Colonel Lambton started working on the network system, but in 1824 Colonel Blacker and Colonel Everest substituted the gridiron system, and by so doing greatly reduced the cost. The whole area of India is almost three times as large as the area triangulated, and as the whole has been controlled by principal fixings, the cost of the triangulation works out at about 3 Rupees per square mile. The cost of a 1 inch = 1 mile survey exceeds generally Rupees 20 per square mile, and amounts at times to Rupees 40 or more. The secondary and tertiary triangulation on which a 1 inch survey is based, will cost 10 Rupees per square mile: the traversing on which a 1 inch survey is based in flat countries, will cost 15 Rupees per square mile. The principal triangulation will, therefore, increase the original cost of a 1 inch survey by less than 10 per cent.,—by less perhaps than the cost of its fair-mapping.

But a 1 inch survey requires to be periodically revised, and the principal triangulation remains available for all revisions. Moreover, surveys on larger scales than 1 inch are in progress throughout the country at costs varying from Rupees 60 to Rupees 200 per square mile, and these are all based on the same principal triangulation. Furthermore, it must be remembered that the true expense of our principal triangulation has not been its total additional cost, but its excess over the cost of the secondary triangulation, which would have had to be substituted, if it had not been executed.

The differences between our principal and good secondary triangulations have been as follows:—

- (a) The principal costs perhaps 20 per cent. more than the secondary.*
- (b) The principal stations are more solidly built, and the positions of the mark-stones are carefully protected for the use of the future.
- (c) Our principal triangulation has generated an error in position of 200 feet and in azimuth of $12''$ between Cape Comorin and Peshawar: our good and expensive secondary work such as the Quetta series, might easily have generated over the same distance an error in position of half a mile and in azimuth of $150''$. Triangulation such as the Kalat series might well have generated between Cape Comorin and Peshawar, an error in position of a mile and a quarter, and in azimuth of $400''$. Secondary work, such as that observed with a 12-inch theodolite on the Cutch Coast, might have generated an error of 5 miles in position and of 20 minutes in azimuth.

Its uses.

It is a great mistake to imagine that the principal triangulation of India was executed for the purpose of measuring the figure of the earth. *The principal triangulation of India was executed to control the topography.* A triangulation, however, furnishes only the distances apart of the points fixed and their mutual directions: these data are not sufficient for topography, which requires the latitudes and longitudes of points. In order to convert the distances and directions of the triangulation into the latitudes and

* Secondary is cheaper than principal in that its progress is faster, but dearer in that its triangles are smaller. In clear weather and suitable country the extra size of the principal triangles will at times compensate the slowness of progress, and render the principal on the whole cheaper than secondary.

longitudes of topography, we require a knowledge of the earth's dimensions. When Lambton commenced the triangulation of India, the figure of the earth was not known with sufficient accuracy even for the calculation of the spherical excesses of his triangles. During his twenty-five years of trigonometrical work he was always, as he extended his triangulation, having to recalculate the earth's figure, and he died without having succeeded in obtaining a satisfactory result. In 1823, Everest attacked the problem, and in the belief that Lambton's arcs had been too short, he extended the triangulation northwards into Central India. To his great disappointment a careful determination then gave the polar diameter of the earth longer than the equatorial. Though this anomaly had been met with in other countries, Everest was convinced that the fault lay in his measurements and not in the theory of gravitation.

It was not till 1830, that Everest succeeded in obtaining a figure of the earth sufficiently accurate for the needs of topographers.

There is no doubt that Lambton's and Everest's unexpected difficulties attracted much attention in Europe: these officers were testing in the field the great Newtonian theory that the earth was an oblate spheroid, and their instructive failures took the scientific world by surprise. But the interest excited in their work does not alter the facts, that the principal triangulation was executed for the control of topography, and that its utilisation for figural determinations was incidental.

The first great practical use of the principal triangulation has been its prevention of embarrassing accumulations of errors at our frontiers.

Its second use has been to unify and co-ordinate all the separate surveys of Madras, Bombay, Sind and Bengal; to give them one origin; to combine them into one harmonious whole: to get rid of gaps and overlaps from the internal mapping of India; to free India from the internal boundary disputes that have so troubled other countries.

Its third use has been to facilitate and cheapen by tower stations, the topographical surveys of the extensive plains of Upper India, a difficult country to map, being the only large portion of the earth's surface that is flat, intricate and valuable.

Its fourth use has been to enable the positions and heights of distant peaks to be determined with accuracy all along our trans-frontier, and thereby to afford points to topographers in Afghanistan and Tibet.

Its fifth use has been to furnish perpetual points for the use of posterity, without which revisions of maps would be impossible.

Its future.

The questions, that arise concerning the future of the principal triangulation, have to do firstly, with the preservation of its stations, and secondly, with its extensions.

The measures that have been taken to preserve the stations have not been altogether successful, and require I think to be supplemented—but not supplanted—by departmental inspections: furthermore, seeing the importance of preserving all these marks intact I think that a call by the Government of India for a special report on the condition of all existing stations, if made every 20 years, would tend to prevent the protective work from degenerating into routine.

The only future extensions of triangulation that require present consideration are those of Burma and Baluchistan. In Burma the completion of the Great Salween series, the extension of the Mandalay Meridional series to Sadiya, and the revision of the Assam Valley, triangles are required to consolidate the triangulation east of Chittagong and Gauhati.

A principal series is being carried westwards from Kalat in order to co-ordinate the separate surveys that have been made of recent years in Baluchistan, and to provide a foundation for other surveys that are likely to be required in those regions in the near future.

If we are to follow the practices of European nations, of the United States, and of South Africa, we should arrange to measure two or three base-lines in Burma, and possibly one in Baluchistan within the next few years.

The following table shows the numbers of base-lines of the first class, measured in various countries:—

	No. of Base-Lines.*	Area triangulated, in thousands of square miles.	Ratio of Base-Lines to area.
Italy	9	110	$\frac{1}{12}$
Germany	13	204	$\frac{1}{15}$
Great Britain	6	121	$\frac{1}{20}$
France	7	207	$\frac{1}{29}$
Russia	19	2,000	$\frac{1}{105}$
India	10	1,520	$\frac{1}{152}$
Burma	0	240	0

* General Ferrero's report to the International Conference at Stuttgart in 1898.

There is a base-line at Mergui in South Burma, but its length of 3 miles is too small to allow of its being classified as first class. The base-lines in India Proper are completed and though it is a matter of regret that the projected base-line at Bombay was omitted, the question is closed: whether our distant successor will re-open it will depend upon the future developments of geodesy.

In the above list there is little doubt that the 2,000,000 square miles allotted to Russia are in excess of her triangulated area: prior to 1895 good triangulation had been carried over Western and Southern Russia, Finland, the Caucasus and the Cis-Caspian Provinces: and a great arc of parallel had been taken eastwards from Warsaw to Orenburg, and was being extended into Central Asia.

THE LEVELLING OPERATIONS.

Their uses.

Levelling operations conducted on scientific principles form as essential a part of a survey as triangulation. Levelling constitutes the framework that controls the vertical measurements of a survey, just as triangulation controls the horizontal measurements. In addition to affording a basis for topographical heights, Levelling contributes to topography by co-ordinating the Canal and Railway levels and rendering them available for maps.

Errors of vertical angles.

The altitudes entered on Indian topographical maps have been mostly derived from vertical angles: the degree of accuracy with which these angles have been measured, has varied from those observed to decimals of a second with large telescopes to those observed to the nearest degree with wooden clinometers. Our levelling operations have brought to light the following errors in the first-class heights of the principal triangulation:—

Madras Coast	.	.	.	.	.	.	.	.	.	5 feet too high
Bombay Coast	.	.	.	.	.	.	.	.	17 "	" "
Mysore	.	.	.	.	.	.	.	.	9 "	" "
Deccan	.	.	.	.	.	.	.	.	7 "	" "
Cutch Coast	.	.	.	.	.	.	.	.	11 "	" "
Khàndesh	.	.	.	.	.	.	.	.	14 "	" "
Punjab	.	.	.	.	.	.	.	.	5 "	" "
Ganges Valley	.	.	.	.	.	.	.	errors varying from	13 "	" "
								to 31 feet too low.		

Errors of height amounting to 20 and 30 feet are of but little importance in mountainous regions, but are liable to mislead engineers who have to study the hydrography of the plains.

To take a well-known example—Ambála is in the Indo-Sutlej basin and its height is 902 feet: Sahárupore is in the Gangetic basin and its height is 903 feet. From Ambála to Sahárupur the ground rises 11 feet in the first 20 miles; the natural watershed between the drainage systems of the Arabian Sea and the Bay of Bengal is 913 feet high near Mustafabad railway station: the ground then falls 7 feet in the 13 miles to the Jumna, and 3 feet in the 17 miles between the Jumna and Sahárupur.

Work in hand.

The work in hand at present in connection with Levelling may be classed as follows:—

- (1) Erection of standard bench-marks.
- (2) Extensions of lines of levelling in the field.
- (3) Preparation of level charts.
- (4) Preparation for press of half a century's levelling results.

The scheme of erecting standard bench-marks has been initiated this winter. From information received at different times there are reasons to fear that numbers of ordinary bench-marks are destroyed, when towns expand and when railways or roads are widened. In the last few years we have discovered that the bench-marks between Rangoon and Mandalay have not maintained their original altitudes: the discovery was accidental; we had not intended to revise the Burmese levels. Revisions in India might bring to light similar displacements. We now propose to erect standard bench-marks in the important towns of India: these new marks will be solidly built in carefully chosen places, and will be handed over to the local engineers who will report to the Survey annually: their heights will be determined by levelling and engraved on the stones.

Projected extensions.

The lines of levelling that remain to be executed may be divided into three classes:—

- (i). The scientific, which are required to close circuits and to furnish the closing errors for the forthcoming adjustment of the level net. These amount to 6 years work.
- (ii). The engineering, which are required by the Public Works Department to control and unify their Canal and Railway levels. These amount to 17 years work.
- (iii). The protective, which are required to fix the heights of our standard bench-marks and to preserve thereby for posterity, a few of the altitudes determined in our time. These amount to 20 years work.

Of these three classes the third is of supreme importance; to postpone, however, the lines of levels required by the Public Works Department for 20 years, is practically to omit them altogether.

For many years past the levelling detachment has been assisting the Public Works Department, and has furnished bench-marks to the Bengal State Railways, to the Burma Railways, to the Irrigation Department and to the Irrigation Department of Sind. There has been no opportunity of completing the scientific lines, which are wanted to consolidate the network.

The preparation of Level Charts was commenced thirty-eight years ago : 34 Charts have been published, and 112 remain. Level Charts are intended to show all Canal and Railway levels in terms of the datum of the Survey, and will be of use to both engineers and topographers.

Comparison with Foreign Surveys.

I have endeavoured to ascertain the amount of levelling executed in Europe and America, but it is difficult to obtain statistics: in all countries the publication of results lags behind the fieldwork.

India : Up to May 1904, there had been executed in India 15,500 miles of precise levelling.

Great Britain: Prior to 1861, the Ordnance Survey had executed 4,000 miles of accurate levelling in England and Wales, 3,000 miles in Scotland and 1,500 miles in Ireland. These operations have been widely extended since 1861.

France: Prior to 1898, France had carried out (a) 7,000 miles of levelling of the highest degree of accuracy, (b) 10,500 miles of a class of levelling, denominated by her surveyors second class, (c) 4,900 miles of so-called third class, (d) 10,200 miles of so-called fourth class. The lower orders of levelling are used in France to break up the fundamental network into smaller areas.*

United States: In 1899, the Survey adjusted their precise level net; 19,753 miles of precise levelling were included in the net: between 1899 and 1903, additional first class levelling extending over 6,000 miles was carried out.*

Germany: Prior to 1892 Germany had carried out 18,600 miles of first class levelling, and Austria had carried out 10,000.*

Japan: Prior to 1898, Japan had carried out and projected 5,700 miles of levelling of precision.*

Ratio of first class Levelling to area :—

Germany in 1892	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{1}$
Great Britain in 1861	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{1}$
Austria in 1892	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{1}$
Japan in 1898	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{2}$
France in 1898	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{2}$
India in 1905	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{2}$
United States in 1899	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{1}{15}$

Seeing how valueless large portions of the Indian area are, no one could advocate that the ratio for India should be raised to that of Great Britain. American surveyors would probably take exception to the ratio allotted to their country, as it makes no allowance for the large unsurveyed regions that form part of the United States.

In adjusting the errors of her levelling net, France had to take into account, that her lines had been connected with those of foreign countries at 18 different points, *viz* :—

- with Spain at three points
with Italy at three points
with Switzerland at five points
with Germany at three points
with Belgium at four points

Owing to the errors in her connections with France, Switzerland had to revise 80 miles of levelling in 1896 and 183 miles in 1897. India's insularity renders her levelling independent of foreign checks.

Their Cost.

Seeing how useful our levelled heights and bench-marks have been in India to the engineering departments, it is questionable whether we ought to charge the total expenditure on them against topography. If, however, we decide to do so, the cost to topography of the levelling control, up to the present time, will work out at about nine annas per square mile of area controlled.

On the average four bench-marks have been erected in every 1-inch standard sheet of surveyed area.

THE ASTRONOMICAL OPERATIONS.

Primary aims.

The primary duty of the Astronomical party is the location of India in its correct position on the globe. The origin of our triangulation is a point in Central India: we have had

* Reports of the International Conferences, Stuttgart 1898, Paris 1900, Copenhagen 1902.

to determine astronomically the terrestrial position of this point, and we have had to determine astronomically the terrestrial directions in which our several diverging series of triangulation have trended; one series has run into Makran, others into the Punjab and Himalayas, others into Assam and Burma, others into South India, and in spite of unremitting care, all these ramifications have developed errors of orientation and direction.

The area of India is more than one-fourth of the total triangulated area of the world: it is the largest triangulated area that has yet been undertaken by one survey; it is the largest triangulated area that has ever been made to emanate from a single point; and our astronomical officers have had to fit this area into its true position on the globe. They have had to discover the relative dimensions of the area to be located and of the globe receiving it: they have had to keep a watch on the triangulation, to see that it is not trespassing beyond our correct frontiers and coasts, and to warn us of the errors that we shall have to deal with when we meet with a foreign survey.

It must be remembered that nature has placed obstacles in the path of astronomical surveyors in India: the direction of gravity is the only test they have of verticality, the surface of liquid at rest is their only test of horizontality, and in no other part of the world has the direction of gravity been found to undergo such abnormal variations, as have been discovered by the Russians in Fergana and by ourselves in Northern India: in no other country does the surface of liquid at rest deviate so much from the horizontal.

There appears to be an idea that the primary object of our astronomical work is the investigation of mountain attraction, and of deflections of the plumb-line. But this is a mistake. Its true goal is the determination of the geographic errors of area, shape, and position, that have been generated by the triangulation. But just as the triangulators found themselves unable to control the topography without a knowledge of the figure of the earth, so have the astronomers found themselves unable to control the triangulation without a knowledge of the direction of gravity. Just as the triangulators had to digress, and make earth-measurements, so have the astronomers had to halt on their way to investigate the attractive effects of mountains.

It is true that discoveries made in the course of these secondary operations have won the interest and sympathy of learned societies in Europe: the discovery that an extraordinary deficiency of matter underlies the Himalayas, that a range of mountains is hidden and buried beneath the plains of Central India, that seaward deflections of gravity prevail round the coasts of southern India,—these discoveries have led geologists and geodesists to press for a further investigation of the distribution of mass in the earth's crust. But the interest that has been awakened does not alter the fact, that the primary object of our astronomical operations is geographic.

The heights of Himalayan peaks.

Difficult questions have arisen in connection with the heights of the Himalayan and trans-frontier peaks: our values for these heights are in error, (*1stly*) because of the extraordinary deformation of the level surface at the observing stations in submontane regions; (*2ndly*) because of our ignorance of the laws of refraction, when rays traverse rarefied air in snow-covered regions; (*3rdly*) because of our ignorance of the variations in the actual heights of peaks due to the increase and decrease of snow. It is part now of the programme of the Astronomical party to determine the errors in height arising from geoidal deformations, to investigate the laws of refraction at high altitudes, and to measure the actual variations that are occurring in the heights of peaks.

There are but three known methods of determining the height of a station, *viz.*, (1) By Spirit Level: (2) By Atmospheric pressure: (3) By Angular measurement. Of these three methods the first two require the station itself to be visited, and the third alone is available, when the station is inaccessible.

To obtain an idea of the degree of uncertainty which attaches to values of heights determined from very distant observing stations, we may suppose that an observer measured the elevation of Mount Everest from Darjeeling in October, and again from the plains of Bengal in April; his second series of observations might give a larger value of height than his first series by 100 feet on account of geoidal deformation, by 300 feet on account of inequalities in refraction,* and by 100 feet or more on account of increase of snow,—by 500 feet in all.

I do not presume to argue that our heights are in error by this amount, but I do say that the above figures give a fair numerical idea of the range of uncertainty. Apart from topographical requirements, it is of interest to the world at large to know the heights of the highest points of the earth, and the duty of determining them belongs to the Indian Survey.

The values of height now attaching to the three highest mountains in the world are by no means the most probable.

Heights of the three highest mountains in the world.

		Present Survey values of height.	Most probable values.
Mount Everest	.	29002	20141
K ₂	:	28250	28191
Kanchinjinga	:	28146	28225

* Refraction is probably less at Darjeeling than over the plains: if, therefore, the same coefficient be employed the height obtained from Darjeeling will be less than that obtained from the plains.

It is possible that we are robbing Kanchinjinga of the honor of second place.

My most probable values of height have been derived from observations of refraction that were not available when the present Survey values of height were adopted. It would, however, be premature to exchange yet our present values for the most probable values, for nothing leads more to confusion than repeated alterations of data.

It is true that the values at present most probably would be improvements on the accepted values, but we want something more than improvement or correction to justify us in changing data: we want finality and certainty, and these we shall never attain, until we appreciate the magnitude of the problem, and go systematically to work. In the course of the Trigonometrical Survey we have accumulated a mass of evidence relating to refraction, but it is entangled with the effects of local attraction and of snowfall, and it cannot be classified or utilised, until we have disentangled the three.

Special duties in the past.

The Astronomical party of the Survey has been often called upon in the past to perform miscellaneous duties that would in Great Britain have fallen upon the staff of Greenwich Observatory. It has had to observe Transits of Venus: in 1894, 1895 and 1896, it was observing in Persia and Europe to determine the error of Indian longitudes: in 1898, it was deputed to assist the Astronomer Royal in observations of the total Eclipse of the Sun. It has worked in conjunction with the Government Astronomer at Madras to obtain a fundamental value of latitude for the Indian Star Catalogue.

Special future work.

The Director of Kodaikánal Observatory requested the Survey some years ago to determine his geographical co-ordinates both astronomically and by triangulation: I regard this request as of first importance, but no officers have been available for the work.

It is to be hoped that in the future the Astronomical party may be given an opportunity of determining the mean density of the earth: Astronomers Royal did this for Great Britain at Schichallion and Cardiff, and the Ordnance Survey made a fine determination at Arthur's Seat at Edinburgh. The three measures were, however, not accordant*, and a determination in the low latitudes of India would be a valuable contribution. The present time is peculiarly opportune, because we could count upon the co-operation of our pendulum party: in no one of the British determinations could astronomical and pendulum observations be combined. When, therefore, the Ordnance Survey had to deduce the weight of the earth from the weight of Arthur's Seat, they were not aware of the density of the crust underlying Arthur's Seat, and they were obliged to assume that it was normal: if we undertook to measure now the relative weights of the earth and Mount Abu, we could with our pendulums discover, whether the foundations of Mount Abu were abnormally heavy or light.

Comparison with Foreign Surveys.

The errors in the geographic position and area and shape of a survey are determined by Astronomical measurements of latitude, longitude and azimuth, at stations of its triangulation. The following table shows the present position of the Survey of India as compared with other surveys: —

Survey of	The proportional number of stations of the triangulation at which Astronomical observations have been made.†		The total number of Arcs of longitude measured.‡
	For Latitude.	For Azimuth.	
Germany	I in 3	I in 4	107
Trans-continental triangulation of America	I in 2	I in 3	67
Great Britain	I in 7	I in 4	‡
Austria	I in 6	I in 7	95
France	I in 8	I in 11	62
Italy	I in 11	I in 12	34
Russia	I in 12	I in 12	81
India proper	I in 11	I in 12	47
Baluchistan	o	o	2
Burma	o	I in 11	5
Kashmir	o	o	0

* Mr. Maskelyne at Schichallion 4·56

Sir George Airy at Cardiff 6·57

Sir Henry James at Edinburgh 5·32

† Reports of the International Conferences at Stuttgart 1899, and at Copenhagen 1903.

‡ Many of the arcs of longitude measured by Great Britain, cross the English Channel and the Atlantic: it is doubtful whether these should be included in the table.

¶ Including the Manipur Meridional series.

Normal future work.

Observations for latitude are still much wanted on branches of our triangulation, more especially in Burma, Baluchistan, Kashmir and the Himalayas.

Observations for azimuth will be required on future extensions of the triangulation.

The measurement of a few additional arcs of longitude in Burma, the Punjab, South India and Kashmir, has for many years been considered desirable.

International determination of the variation of latitude.

Of recent years endeavours have been made in Europe and America, to measure the changes in the positions of the earth's centre of gravity and of the earth's rotation axis; that changes are always going on has been made clear by the discovery that the latitude of every place is continually varying. Some few years ago an International Congress decided that a systematic investigation should be made, and they suggested that the earth should be surrounded by a girdle of special observatories. The parallel of 39° north was selected for the girdle, with the result that three observatories fell in the United States, one in Japan, one in Russia, one in Sardinia. The Russian Government was asked in accordance with this scheme to erect an observatory at Tschardjui : Russia had been already for some years observing the variations of latitude at Pulkowa, at Moscow, at Warsaw, and at Kazan, and the new observatory at Tschardjui made her fifth. India has so far not been asked to contribute to this work : she profits nevertheless from the results.

THE PENDULUM OPERATIONS.

The progress of foreign surveys.

The number of stations, at which the pendulum had been observed prior to 1903, were*—

Great Britain	.	.	.	.	.	.	.	.	.	.	.	.	63
Italy	.	.	.	.	.	.	.	.	.	.	.	.	193
France	.	.	.	.	.	.	.	.	.	.	.	.	89
Austria	.	.	.	.	.	.	.	.	.	.	.	.	569
Germany	.	.	.	.	.	.	.	.	.	.	.	.	280
United States	.	.	.	.	.	.	.	.	.	.	.	.	108
Russia	.	.	.	.	.	.	.	.	.	.	.	.	153
India	.	.	.	.	.	.	.	.	.	.	.	.	29

Pendulum observations are now being taken by the surveys of France, Germany, Russia, Austria, Italy, Japan and the United States.

France has volunteered to undertake a gravimetric survey of the Andes : Germany has undertaken one of the oceans and coast lines of the world ; the United States and Russia have enormous areas of their own ; and Great Britain sent a complete pendulum equipment to the Antarctic two years ago.

But, for pendulum research the most interesting place on the earth is the mountainous region of Northern India, and the International Conference that met at Copenhagen in 1903, passed the following resolution on this subject for submission to the Government of India.†

"Il est desirable qu'on fasse dans les Indes anglaises une étude approfondie de la répartition de la pesanteur, tant dans les contrées montagneuses que dans les plaines.

"Attendu que c'est seulement par cette étude qu'on pourra obtenir une représentation exacte de la distribution des masses dans l'écorce terrestre et de la forme du géoïde dans ces contrées."

The British Ambassador at Berlin submitted the above resolution to the Government of India on October 6th, 1903. Pendulum observations were commenced in India in 1904.‡

The purposes served by Pendulum observations.

Pendulum observations are of use—

(1stly).—For correcting and perfecting our astronomical checks on the triangulation.

(2ndly).—For determining the earth's ellipticity by a method independent of arc-measurements.

(3rdly).—For investigating the departures of the geoid from a Newtonian spheroid.

(4thly).—For investigating the constitution of the earth's crust.

The first purpose served by pendulum observations is, therefore, geographic, the second and third are astronomic, the fourth is geologic ; all are geodetic.

We are profoundly ignorant of the constitution of the earth : we do not know if its interior is rock or metal, solid or molten : we talk of its crust, but we do not know if it has a crust distinct from its core : we do not know if the existence of high mountains is an incident of the earth's surface only, or if their superincumbent weight is producing inequalities of density at great depths. We do not know how these mountains have arisen. Pendulum operations have consequently a high value and interest for geologists and geodesists.

* Reports of the International Conferences at Paris in 1900 and at Copenhagen in 1903. Observations at 29 pendulum stations in India were made between 1866 and 1871: the work was stopped because the only apparatus procurable was too heavy and wearisome. Of the 63 stations appertaining to Great Britain, but 16 fall in Great Britain itself : the remainder, though occupied by British observers, fall in Spitzbergen, South America, and other places.

† See A proceedings No. 2, December 1903, Department of Revenue and Agriculture, Government of India.

‡ The Surveyor General had obtained the sanction of Government to the purchase of a pendulum apparatus in 1902, and thus anticipated the wish of the International Conference.

Geographical, astronomical and geological observations have all in their turn revealed peculiar physical features in the Himalayas, and we are now calling the pendulum to our aid to supplement our knowledge of Himalayan structure.

But when discussing the numerous uses of pendulum observations, we must not lose sight of the important fact that the pendulum is primarily a surveying instrument.

The connection between topography and pendulum work is, however, too complex to be described clearly in a single sentence, and must be traced step by step, as follows:—

- (i) The geographical adjustment of the triangulation is dependent upon astronomical observations.
- (ii) The correctness of astronomical observations depends upon the direction of gravity.
- (iii) We cannot *measure* the direction of gravity, because we have no zero from which to measure. We can measure the *height* of a station, because the mean level of the sea is a reliable zero, we can measure *temperatures*, because the freezing point of water is a reliable zero: we can measure the deviation of the needle from true north. But we cannot measure the deviation of gravity from the true vertical, because the true vertical is not discoverable by observation as the true north is.
- (iv) Owing to the deflections of gravity, astronomical measurements may cause an error of 800 or 1,000 feet in the geographical position of any point, and an error of a mile in the position of a Himalayan point.
- (v) No deflections of gravity would occur on a perfectly level spheroid formed of homogeneous spheroidal layers: they are caused by the irregular distribution of masses at the earth's surface and in the earth's crust. The pendulum is required to demonstrate the true distribution of mass, and to show to us the extent to which our actual earth differs from a level spheroid composed of homogeneous layers.
- (vi) If we know the mean density of the earth and the local distribution of mass at its surface, we can calculate the amount that gravity will be deflected from the normal. By providing us, therefore, with an ideal spheroid the pendulum supplies the zero which nature has failed to furnish.

The primary use then of pendulum work is that it enables the surveyors to correct their astronomical results for the unavoidable errors caused by deflections of gravity. The location of India on the globe has, for instance, rested upon astronomical observations made at a point in Central India. Everest selected this spot because there were no mountains visible, and because it seemed to be a place at which the direction of gravity would be truly vertical, and at which the instrumental levels would be truly horizontal. But only in the last few years we have discovered that Everest's point is situated on the scarp of a buried range or table-land; this range is deflecting gravity out of the normal, and must have disturbed the horizontality of Everest's levels; pendulum observations will disclose the mass and position of the hidden range, and will enable us to compute corrections for the astronomical results.

Thus it will be seen that pendulum observations are used to control astronomical results, just as astronomical observations are used to control the triangulation, and as the triangulation is used to control the topography: all are links in one chain.

THE TIDAL OPERATIONS.

Retrospect.

The investigations and writings of Professor George Darwin have within the last thirty years, considerably increased our knowledge of the tides. Though we are still unable to foretell the course of the tides at places where no observations have been taken, yet our predictions at ports at which the tides have been observed, are now attaining an accuracy which would not have been credited half a century ago.

Tidal operations in India were initiated for the following purposes:—

- (1) To provide a datum for the levelling operations of the survey.
- (2) To afford data for the calculation of tidal predictions.
- (3) To obtain evidence of the rising and sinking of land and of variations in mean sea-level.

Up to 1883, predictions of the tides were calculated by an arbitrary method which made no allowance for what is known as the diurnal inequality.*

In home waters the diurnal inequality is practically absent; and the European admiralties and surveys have never been really troubled by it. But in Indian waters it is very large, so large that in some of our ports at certain times there is only one tide in 24 hours. Owing to this phenomenon the earliest attempts at tidal prediction which were made in India, for Karachi and Bombay, were not successful; and for many years all endeavours to foretell the tides at Aden failed. In 1883, Darwin revised the method of Harmonic Analysis as applied to the tides, formulated by Sir William Thomson in 1872, and we are now able to unravel their extreme complication in Indian waters. The average error in the

* This inequality is easily understood from a diagram.

predicted height of high water at Aden is now one inch. If we reflect that the motions of the sun and moon, the complex outline of our coasts, the ever-varying depths of the sea, and the earth's rotation and figure are all involved, we cannot but regard modern tidal prediction as one of the greatest triumphs of science.

India was the first country to adopt this method of prediction : her success has been extraordinary, and her example has been slowly followed by Canada, the United States, by France, and other European nations.

By means of Harmonic Analysis we can separate the observed tides into twenty-four components, and by means of Lord Kelvin's tide-predicting machine we can again combine these components, and discover mechanically the actual tides of the future. For many years India was the only country that possessed a tide-predicting machine : but latterly France, the United States, and Canada have had machines constructed. The tide-predicting machine of the Indian Government has been used in Europe for the tidal predictions of British colonies, and for this reason has never been sent to India. For many years it stood at Lambeth, but has lately been received at the National Physical Laboratory at Teddington.

The predictions of the Indian tides are carried out under the following quadruple arrangement :—

(i). The tidal observations are taken under the superintendence and orders of the local port officers and engineers.

(ii). The Survey of India has the duty of inspecting the several tidal observatories and of maintaining uniformity of method : the Survey of India has the further duties of reading off the tidal diagrams and of calculating by Harmonic Analysis the twenty-four tidal components.

(iii). The National Physical Laboratory in England sets the tidal machine to accord with the results of our calculations, and prepares the tidal predictions from the curves drawn by the machine.

(iv). From the beginning, the operations have been under the scientific direction of Professor Darwin, whose advice has been constantly sought.

If tidal observations are taken for 5 years, sufficient data are accumulated to enable predictions to be made ; the present predictions for some of the Indian ports are being still based upon observations taken more than twenty years ago and continue to be accurate. But lest in the course of years the tides may be slowly varying, or lest the relative heights of sea and land may be altering, a few observatories have been established on a permanent basis.

Between 1874 and 1904, tidal observations were taken at 42 places : of these observatories 34 were temporary and 8 permanent. At the present time one temporary observatory and the eight permanent are working.

Of our 42 tidal observatories two were in the Red Sea, two in Arabia, one in the Persian Gulf, one in the Maldives, three in Ceylon, one in the Andamans, twenty-four in India and eight in Burma.

Comparison with foreign surveys.

The levelling results have been tested against tidal determinations of mean sea-level at 20 different places on the coasts of India.

In Great Britain, prior to 1861, the levelling results of the Ordnance Survey had been compared with tidal measurements of sea-level at 30 places in England and Wales, at 18 places in Scotland and at 21 places in Ireland.*

The following table shows the number of permanent tidal observatories working in 1902 :†—

Country.	Length of Coast-line in miles.	No. of tidal Observatories.
Tonquin (France).	150	1
Austria	300	1
Holland	400	20
Denmark	500	10
Algiers (France)	600	1
Germany	800	26
New South Wales	800	3
France	1,300	11
Italy	1,600	16
Canada	2,000	7
Russia	2,000	10
Japan	2,600	10
New Zealand	3,000	6
Great Britain	3,000	9
India	4,000	8

* Abstracts of Spirit Levelling, Ordnance Survey, 1861.

† International Conferences, Stuttgart, 1898, and Copenhagen, 1903.

Future work.

The following tidal work will be carried out by the Survey of India in future :—

- (i). Maintenance of 8 permanent tidal observatories.
- (ii). Annual calculations for the tide-predictions for 42 different ports.
- (iii). Opening of new tidal observatories, of which two have been proposed for the Malay Peninsula, one for the Red sea and two for the Gulf of Cutch.

Scientific Investigations.

Up to a few years ago it was generally held by geologists that the earth was a globe of molten matter enclosed by a thin crust. Lord Kelvin has, however, shown that such a globe would yield to tidal forces, and that the oceanic tides would then be imperceptible. The oceanic tides consist in a motion of the water relatively to the land, and their existence proves that the land does not yield with perfect freedom. From the fortnightly tide observed in Indian waters, Lord Kelvin and Professor Darwin have shown that the earth possesses a rigidity greater than that of solid glass, though not greater than that of solid steel.

In my previous note on Astronomical work I alluded to the variation of latitude : this phenomenon has been attributed to shifting of the earth's axis of rotation, to movements of the earth's centre of gravity, and to variations in the position of the equatorial protuberance with reference to places fixed on the earth's surface: as the axis of rotation and the centre of gravity and the equatorial protuberance shift, the oceans become disturbed, and a tide becomes generated. We are endeavouring now under the direction of Professor Darwin, to detect a tide at Karachi corresponding in its period of 430 days with the variation of latitude : the United States Geodetic Survey have discovered such a tide on their coasts, and the Geodetic Survey of Holland has also detected it. This tide is of course minute, as the movements of the earth's axis are small : if the displacements of the axis were considerable, whole continents would be drowned by gigantic waves.*

THE MAGNETIC SURVEY AND SOLAR PHOTOGRAPHY.

A Magnetic Survey of India was proposed in 1896 by Sir John Eliot and General Strahan, and was recommended by the Astronomers who visited India in 1898, on the occasion of the total eclipse of the sun.† At the outset there was some uncertainty as to whether the work should be undertaken by the Survey of India or by the Meteorological Department, and it was eventually decided that the field work should be carried out under the Surveyor General, and that the fixed observatories should be under the Meteorological Reporter. By mutual agreement, however, the Meteorological Reporter has now handed over the charge of four of the five observatories to the Surveyor General. The Magnetic Survey of India was begun in 1900.

Many branches of science are interested in a Magnetic Survey : the meteorologists require it to assist them in their investigation of the connection between sunspots and rainfall: the geologists expect it to show them the positions of magnetic rocks: geographers and navigators derive from it their knowledge of the declination of the compass, and the secular changes in the declination. ,

The existence of magnetic rocks in the crust can at times be detected by ordinary compasses, but if iron ore is lying concealed at any great depth from the surface, its presence would be only discovered by a systematic and rigorous survey.

Though the magnetic surveys of Europe and America have greatly progressed of recent years, but a small fraction of the surface of the globe has as yet been examined. We do not at present know whether the earth's magnetism is due to permanent centres of attraction or to its rotatory motion: we do not know whether the earth is a permanent magnet or not.

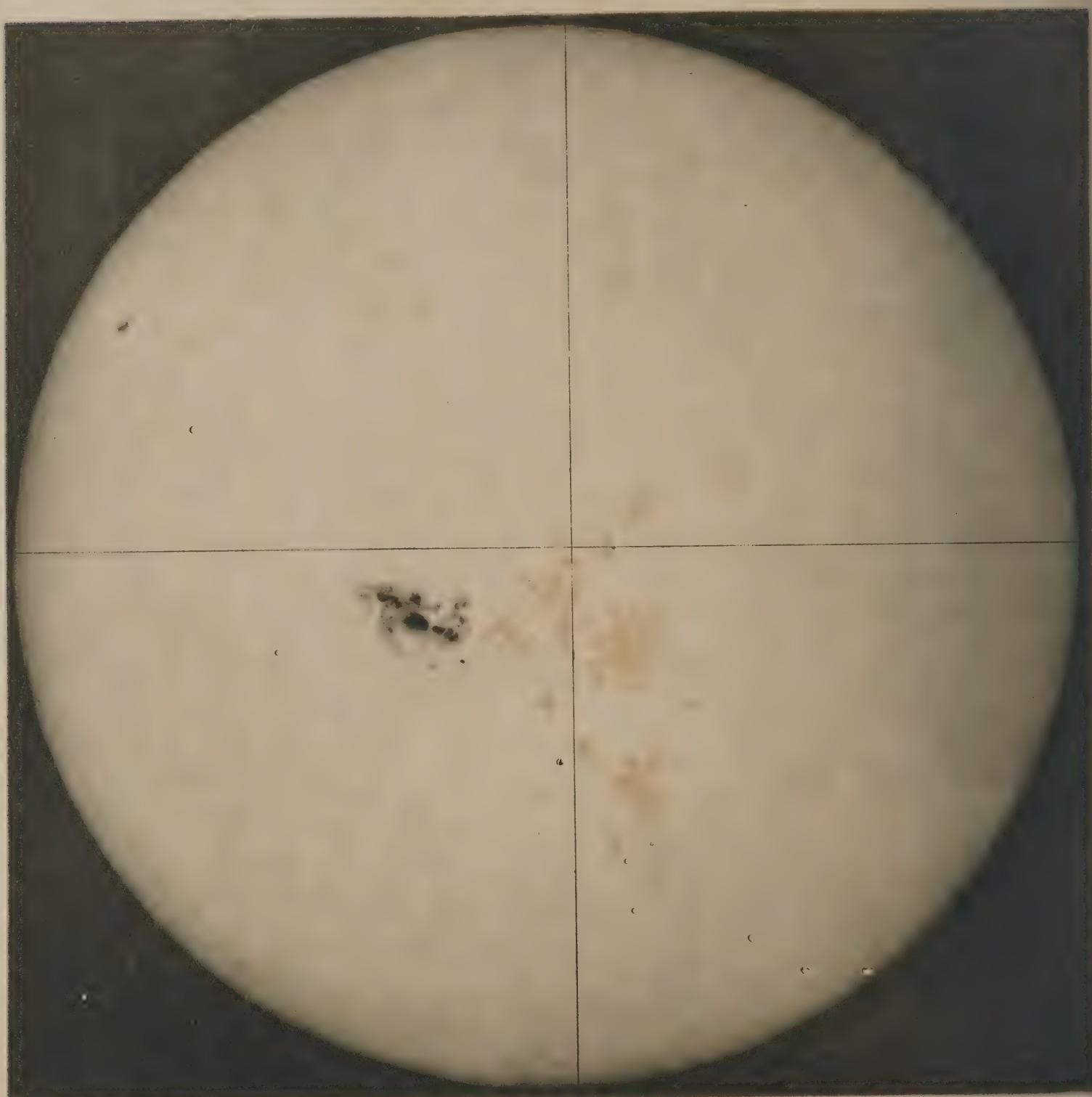
Date of Magnetic discoveries.

- 1492. Discovery that a needle does not point true north, and that its declination differs in different parts of the earth.
- 1576. Discovery that the north end of a needle if properly balanced will dip below the horizon, and that the amount of dip differs in different parts of the earth.
- 1634. Discovery that the magnetic declination constantly undergoes slow changes in the course of years, and that the rate of its change differs in different countries.
- 1720. Discovery that the strength or intensity of the earth's magnetic force differs in different countries, and at different times.
- 1722. Discovery that the magnetic declination is subject to an appreciable diurnal tide, and that the range of this tide differs in different countries and at different seasons.
- 19th century. General Sabine shows that the earth's magnetism is not only a telluric but a cosmical force.

* Darwin's Tides: p. 230.

† See Reports by Sir W. Christie, K.C.B., F.R.S. and Sir Norman Lockyer, K.C.B., F.R.S.

PHOTOGRAPH OF THE SUN TAKEN AT DEHRA DUN ON FEBRUARY 3rd 1905.



Survey of India Offices, Calcutta, June 1905.

THE SUNSPOT IN THE ABOVE PICTURE IS THE LARGEST
THAT HAS BEEN PHOTOGRAPHED AT DEHRA DUN.

Relative size of the Earth ○

at Mauritius. For many years Greenwich, Dehra Dún and Mauritius have acted together under one scheme and on one system. We send our photographs to England weekly to Sir Norman Lockyer, K.C.B., F.R.S., under whose directions we have carried out the work from its inception. In 1898 Sir William Christie, the Astronomer Royal, wrote to the Secretary of State: "The daily photographs of the sun should be continued at Dehra Dún, where they are being taken satisfactorily under the Surveyor General's direction."*

Note by Lieutenant-Colonel S. G. BURRARD, F.R.S., R.E., on a large sunspot observed in January 1905.

A photograph of the sun taken at Dehra Dún at 9 A. M. on January 29th, 1905, revealed the existence of a sunspot of exceptional magnitude which was just appearing round the sun's limb.

The spot originated on the further side of the sun from the earth, and it is not, therefore, known whether it attained its full dimensions in a few minutes, or whether its growth continued for several days.

Every point of the surface of a rigid body like the earth, rotates round its polar axis in the same period: but in the case of the sun certain portions of the surface complete a rotation in a shorter period than others. A spot on the sun's equator rotates in 25 days, whilst a spot half way between the equator and the poles takes 27½ days.

It is not easy to measure the exact rotatory period of any particular spot, because spots have proper motions of their own on the sun's surface.

An object near the limb of globe is necessarily foreshortened, but when on January 29th the rotation of the sun brought a new spot into view, it was evident at once that within the preceding fortnight the portion of the sun's surface away from the earth had suffered a disturbance of unusual violence.

As the sun rotated after January 29th, the foreshortening decreased daily; during the first week of February the spot faced the earth and its real dimensions could then be estimated. There is no apparatus in India for measuring the areas of spots, and the sun-photographs are despatched weekly to England. Some idea, however, of the size of the sunspot of February 1905, can be obtained by comparing it with the earth, and for this purpose the earth has been drawn to scale on the plate showing the sunspot. After February 6th, the spot became daily more and more foreshortened, on February 10th, it had reached the sun's further limb, and on February 11th, it had been removed from our view.

Abstract showing the approximate magnetic values at stations observed at by No. 26 Party during season, 1903-04.

Serial No.	Name of Station.	Survey No.	Latitude.	Longitude.	Dip.	Declination.	Horizontal Force.	REMARKS.
			°	'	"	°	'	
371	Ratagaon (Vijá-pur).	20 8	19 56 40	74 45 50	24 55	E 0 50	0.3685	
372	Aurungábád .	20 3	19 51 30	75 20 20	24 35	" 0 50	0.3695	
373	Jálma .	4	19 51 50	75 53 00	24 35	" 1 5	0.3685	
374	Satona .	5	19 29 30	76 21 30	23 40	" 0 55	0.3710	
375	Parbhani .	6	19 15 20	76 46 50	23 30	" 0 55	0.3715	
376	Nander .	20 1	19 9 30	77 18 10	23 30	" 0 20	0.3705	
377	Dármávád (Bálápur).	20 1	18 53 10	77 51 30	22 35	" 0 30	0.3730	
378	Upalwai .	2	18 25 10	78 19 20	21 35	" 0 35	0.3740	
379	Masapet .	3	17 52 40	78 27 30	20 15	" 0 10	0.3750	
380	Alir .	20 2	17 38 30	79 2 50	19 50	" 0 30	0.3770	
381	Warangal .	1	17 58 40	79 36 50	22 20	" 0 25	0.3755	
382	Mánukota .	3	17 36 00	80 0 10	19 25	" 1 10	0.3805	
383	Bona Kalu .	4	17 2 00	80 15 50	18 35	" 0 0	0.3775	
384	Bezwada .	20 1	16 31 00	80 36 50	17 10	" 0 0	0.3805	
385	Bapatla .	2	15 54 30	80 27 40	16 25	" 0 35	0.3775	
386	Ongole .	3	15 30 20	80 3 20	13 45	" 2 10	0.3455	
387	Bitragunta .	20 7	14 48 40	79 57 20	13 40	W 0 35	0.3805	
388	Arambákkam .	8	13 32 40	80 4 30	10 50	" 0 20	0.3820	
389	Acharapákkam	20 9	12 24 10	79 49 10	6 50	" 0 55	0.3780	
341	Villupuram .	5	11 56 40	79 29 50	...	E 0 15	...	Declina- tion only re-observ- ed.
390	Eringi .	10	11 35 50	79 10 20	5 35	W 0 25	0.3775	
391	Atúr .	20 10	11 35 40	78 36 50	6 25	" 0 25	0.3840	
392	Perambalúr .	12	11 14 10	78 51 50	5 30	" 0 35	0.3835	
393	Pudukottái .	20 4	10 22 50	78 48 50	3 40	" 0 30	0.3795	

*Abstract showing the approximate magnetic values at stations observed at by No. 26
Party during season, 1903-04.—contd.*

Serial No.	Name of Stations.	Survey No.	Latitude.			Longitude.			Dip.	Declination.	Horizontal Force.	REMARKS.
			°	'	"	°	'	"				
394	Satubara Chatram	10 8 5	10 14 50	79 16 50	2 40	W 0 35	0.3805					
395	Tiruppattur	11	10 7 10	78 36 00	2 55	" 0 55	0.3805					
396	Nattam	10	10 13 40	78 14 00	3 0	" 0 40	0.3790					
397	Palmaner	14	13 12 20	78 44 50	9 45	" 0 25	0.3805					
398	Madanapalle	19	13 34 40	78 30 30	10 35	" 0 15	0.3810					
399	Páragada	12	14 6 20	77 17 10	12 0	E 0 0	0.3795					
400	Kalyán-drug	11	14 32 50	77 0 40	13 15	W 0 20	0.3765					
401	Hangal	6	14 44 10	76 41 50	13 5	" 0 5	0.3785					
402	Chalakere	8	14 19 00	76 39 00	12 20	" 0 5	0.3795					
403	Hiriýúr	10	13 56 30	76 36 40	11 25	" 0 5	0.3790					
1	Pavdásán	3	24 29 20	71 53 50	33 45	E 1 10	0.3520					Re-observ. ed.
2	Sáchor	2	24 45 20	71 45 50	33 55	" 1 40	0.3520					do.
3	Dutwa	1	24 52 50	71 28 50	34 0	" 2 0	0.3495					do.
4(a)	Sheria Bheel (a)	2 4 0	24 43 50	70 52 50	33 25	" 1 45	0.3500					do.
5	Tur Loonian	2	24 39 00	70 31 40	34 5	" 2 15	0.3505					do.
6(a)	Islám-kot (a)	3	24 42 10	70 9 50	33 35	" 1 20	0.3545					do.
7(a)	Dipla (a)	4	24 28 00	69 34 30	33 25	" 2 0	0.3480					do.
8	Rahím-ki-Bazár	5	24 19 00	69 9 00	32 55	" 1 50	0.3495					do.
9	Kirria	3	24 20 00	68 46 40	32 45	" 1 40	0.3500					do.
10(a)	Lachpat (a)	4	23 49 20	68 46 20	31 55	" 1 45	0.3510					do.
11(a)	Murr (a)	5	23 33 20	68 56 40	31 45	" 2 0	0.3520					do.
12(a)	Nakhtrana (a)	6	23 20 50	69 15 10	31 30	" 1 35	0.3525					do.
13	Kalyánpur	8	23 13 40	69 35 40	30 55	" 1 15	0.3555					do.
14	Bhimasar	9	23 11 20	70 9 50	30 30	" 1 5	0.3525					do.
15(a)	Lákadiya (a)	7	23 20 30	70 34 40	31 30	" 1 5	0.3510					do.
16(a)	Adesar (a)	10	23 33 30	70 59 10	31 35	" 1 15	0.3545					do.
17	Váráhi	10	23 47 50	71 26 20	31 55	" 1 25	0.3545					do.
18	Diodar	7	24 6 30	71 46 10	32 25	" 1 30	0.3550					do.
404	Lohana (Jas-want-pura).	14	24 47 20	72 27 10	33 40	" 1 35	0.3540					
405	Jálor	12	25 21 10	72 36 50	34 40	" 1 20	0.3500					
406	Mandaula G. T. S.	11	25 24 50	71 52 10	35 5	" 2 0	0.3515					
407	Wallar	9	26 29 10	71 48 40	39 55	" 2 20	0.3470					
408	Mandai, G.T.S.	10	26 21 10	71 10 40	36 20	" 1 50	0.3460					
409	Jejrawa	13	26 15 20	70 38 50	36 15	" 2 0	0.3445					
410	Rávíláhu, G.T.S.	12	26 52 40	70 2 20	37 25	" 2 10	0.3425					
411	Khubba	11	26 49 10	70 40 10	37 25	" 2 10	0.3425					
412	Kakrasar	8	26 55 40	71 12 10	37 35	" 2 25	0.3430					
413	Hardikot, G.T.S.	7	26 57 30	71 51 00	38 35	" 3 5	0.3390					
414	Satiaya	14	27 25 20	71 39 10	38 15	" 2 40	0.3380					
415	Deega	15	27 24 20	71 0 0	38 25	" 2 20	0.3400					
416	Kolu, G.T.S.	14	27 25 10	70 17 30	38 25	" 2 10	0.3405					
26	Reti	3	28 5 10	69 51 20	39 25	" 2 40	0.3365					Re-observ. ed.
54(a)	Sibi (a)	1	29 32 40	67 51 40	41 50	" 2 45	0.3275					do.
417	Lehri	11	29 10 40	68 12 40	41 15	" 2 20	0.3300					
418	Chirdi Dhabbar	12	29 5 20	68 43 10	40 55	" 2 25	0.3310					
419	Derah Bugti	15	29 2 00	69 9 20	40 50	" 2 35	0.3315					
420	Chat	14	29 20 20	69 24 30	41 25	" 2 40	0.3305					
421	Mat	13	29 42 20	69 40 00	41 55	" 2 50	0.3290					
422	Rakni	12	30 2 50	69 55 30	42 25	" 3 0	0.3285					
423	Kingri	11	30 26 20	69 49 00	43 5	" 3 5	0.3265					
424	Músa-Khel Bazár	9	30 52 30	69 48 50	43 45	" 3 10	0.3245					
425	Mekhtar	10	30 29 00	69 20 20	43 5	" 2 55	0.3260					
426	Fort Sandeman	7	31 20 40	69 27 10	44 25	" 3 15	0.3220					
427	Musáfrpur	8	30 58 00	69 8 30	43 50	" 3 0	0.3240					
428	Kalu Killa	7	30 41 40	68 43 20	43 25	" 2 55	0.3250					
429	Killa Saifulla	6	30 42 50	68 21 10	43 25	" 3 5	0.3240					
430	Hindu Bagh	5	30 49 20	67 44 30	43 40	" 3 0	0.3220					
431	Chinjan	8	30 34 10	67 55 50	43 0	" 3 0	0.3240					
432	Loralai	9	30 21 30	68 36 30	42 55	" 2 50	0.3255					
433	Puzza	10	29 54 00	68 42 40	42 15	" 2 45	0.3275					
434	Ferozepore	12	30 57 50	74 36 10	44 30	" 2 30	0.3250					
435	Moga	14	30 49 40	75 10 30	44 0	" 2 55	0.3295					
69	Ladhowál	1	30 59 00	75 47 20	44 20	" 2 55	0.3290					Re-observed
436	Mahábaleshvar	7	17 55 50	73 39 40	20 35	" 0 5	0.3680					
437	Helwák	8	17 22 20	73 43 10	10 5	" 0 40	0.3715					
438	Ámba	7	16 58 20	73 47 50	19 10	" 0 20	0.3715					
439	Dájeepur	8	16 22 40	73 52 40	17 30	" 0 5	0.3755					
440	Rámghat	9	15 49 40	74 6 20	15 45	" 0 35	0.3660					
441	Yellápur	1	14 57 40	74 42 30	13 55	W 0 5	0.3765					
442	Banvási	7	14 32 20	75 1 10	13 5	" 0 5	0.3770					

*Abstract showing the approximate magnetic values at stations observed at by No. 26
Party during season, 1903-04.—contd.*

Serial No.	Name of station.	Survey No.	Latitude.	Longitude.	Dip.	Declination.	Horizontal Force.	REMARKS.
			°	'	"	°	'	
443	Mauvinhola	7 6 9	13 59 10	75 6 20	11 45	W 0 5	0'3775	
444	Koppa	7 6 11	13 31 50	75 19 30	10 35	" 0 25	0'3785	
445	Beltángády	7 6 8	12 59 10	75 17 00	9 40	" 0 25	0'3780	
446	Sullia	7 6 12	12 34 20	75 23 20	8 40	" 0 15	0'3770	
447	Sáklespur	7 6 9	12 56 40	75 47 30	9 15	" 0 20	0'3790	
448	Dárdigánhálli	7 6 10	12 58 20	76 16 50	9 10	" 0 15	0'3785	
449	Yediyur	7 6 11	12 58 40	76 51 20	9 15	" 0 15	0'3795	
450	Singánallúr	7 6 8	12 8 30	77 13 00	7 50	" 0 15	0'3825	
451	Kávéripur	7 6 9	11 54 20	77 45 30	7 45	" 0 25	0'3790	
452	Satyamangalam	7 6 11	11 30 00	77 14 20	6 15	" 0 25	0'3835	
453	Gundlupet	7 6 13	11 48 20	76 41 20	6 40	" 0 30	0'3810	
454	Sultan's Battery	7 6 14	11 39 40	76 15 30	6 25	" 0 30	0'3815	
455	Ootacamund	7 6 15	11 24 30	76 42 50	5 45	" 0 30	0'3805	
456	Nilambúr	7 6 16	11 16 20	76 13 20	5 25	" 0 30	0'3785	
457	Anamalais	7 6 3	10 34 50	76 56 00	4 5	" 0 45	0'3805	
458	Dhárápuram	7 6 8	10 43 30	77 31 20	4 30	" 0 50	0'3840	
459	Periyakulam	7 6 9	10 7 40	77 33 20	3 0	" 1 10	0'3835	
460	Top Station (Kanan Devan hills),	7 6 12	10 6 40	77 13 20	3 50	" 0 10	0'3795	
461	Munnar	7 6 12	10 4 10	77 3 20	3 5	" 0 35	0'3805	
462	Nyamakad Estate (Kanan Devan hills).	7 6 12	10 8 10	77 3 10	3 0	" 0 40	0'3810	
463	Kuravanath.	7 6 13	9 38 50	77 12 30	2 0	" 1 0	0'3815	
464	Kanjarapalli	7 6 8	9 33 00	76 46 50	1 25	" 1 0	0'3780	
465	Alleppi	7 6 7	9 29 50	76 19 10	0 30	" 1 0	0'3745	
466	Quilon	7 6 2	8 53 30	76 36 00	-0 25	E 0 10	0'3780	
467	Punalur	7 6 9	9 1 20	76 55 30	0 45	W 1 0	0'3795	
468	Tenkási	7 6 6	8 58 00	77 18 30	0 35	" 1 0	0'3805	
469	Virudupatti	7 6 14	9 35 50	77 57 40	0 45	" 1 10	0'3835	
470	Manapád	7 6 3	8 22 20	78 4 00	-1 0	" 1 5	0'3800	Do.
471	Nágarkoil	7 6 5	8 11 20	77 26 00	-1 25	" 1 5	0'3785	Do.
472	Trivandrum	7 6 4	8 28 50	76 55 30	-0 30	" 0 50	0'3800	Do.
473	Cochin	7 6 5	9 57 50	76 14 00	2 55	" 0 35	0'3810	
474	Kodhamangalam	7 6 6	10 3 40	76 37 40	2 40	" 1 0	0'3775	
475	Irinjalakuda	7 6 4	10 20 20	76 13 00	4 5	" 0 55	0'3790	
476	Lucknow	7 6 2	26 50 00	80 55 20	37 45	E 1 55	0'3510	
477	Rae-Bareli	7 6 3	26 14 00	81 14 40	36 25	" 1 45	0'3550	
478	Amethi	7 6 5	26 9 20	81 48 40	36 30	" 1 55	0'3540	Visited by two obser- vers.
479	Suriawán	7 6 8	25 28 00	82 25 50	35 15	" 1 50	0'3585	
480	Chunár	7 6 10	25 6 10	82 52 30	34 40	" 1 35	0'3605	
481	Allahabad	7 6 7	25 27 30	81 49 20	35 3	" 1 40	0'3585	
482	Kunwar	7 6 6	25 42 00	82 13 10	35 45	" 1 50	0'3530	
483	Mánikpur	7 6 9	25 3 10	81 5 20	31 30	" 1 35	0'3590	Visited by two obser- vers.
484	Karmnása	7 6 11	25 14 30	83 25 20	35 0	" 1 40	0'3590	
485	Japla	7 6 2	24 32 30	84 0 00	34 5	" 1 10	0'3645	
486	Daltonganj	7 6 3	24 2 00	84 4 30	32 30	" 1 35	0'3665	
487	Palmerganj	7 6 1	24 51 40	84 19 50	34 35	" 1 25	0'3605	
488	Nawádah	7 6 1	24 52 30	85 32 50	34 10	" 1 30	0'3645	
489	Monghyr	7 6 8	25 23 10	86 27 50	35 10	" 1 40	0'3620	
490	Bhágalpur	7 6 9	25 14 00	86 57 40	35 5	" 1 25	0'3625	
491	Sáhebganj	7 6 2	25 14 50	87 38 20	34 55	" 1 30	0'3650	
492	Pakaur	7 6 1	24 33 50	87 51 40	33 50	" 1 25	0'3640	
493	Azimganj.	7 6 2	24 14 10	88 15 10	33 15	" 1 20	0'3685	
494	Sainthia	7 6 3	23 56 50	87 41 20	32 40	" 1 15	0'3670	
495	Búrdwan	7 6 5	23 15 00	87 52 40	31 15	" 1 15	0'3700	
496	Calcutta	7 6 3	22 33 40	88 17 30	29 55	" 1 20	0'3725	
497	Ulubaria	7 6 4	22 28 20	88 6 20	29 40	" 1 5	0'3730	
498	Midnapore	7 6 2	22 25 20	87 17 30	29 50	" 1 10	0'3730	
499	Ghátsila	7 6 2	22 35 00	86 28 20	30 10	" 1 20	0'3705	
500	Sini	7 6 1	22 47 00	85 56 50	30 5	" 1 20	0'3725	
501	Purulia	7 6 6	23 19 30	86 22 50	31 15	" 1 30	0'3725	
502	Bankura	7 6 6	23 13 30	87 4 10	31 20	" 1 30	0'3710	
503	Garhbeta	7 6 1	22 50 40	87 18 50	31 5	" 0 55	0'3710	
504	Rániganj.	7 6 4	23 35 30	87 7 30	31 40	" 1 25	0'3700	
505	Kátrásgarh	7 6 5	23 48 00	86 18 00	32 15	" 1 25	0'3675	
506	Giridih	7 6 4	24 10 50	86 19 20	32 50	" 1 25	0'3660	
507	Baidyanáth	7 6 3	24 30 50	86 38 00	33 35	" 1 35	0'3655	
508	Gidhaur	7 6 2	24 52 20	86 18 00	34 15	" 1 35	0'3640	
509	Barh	7 6 7	25 28 20	85 42 50	35 40	" 1 45	0'3605	
510	Patna	7 6 5	25 35 30	85 12 20	35 30	" 1 35	0'3595	
511	Jahánabad	7 6 6	25 13 40	84 59 50	34 55	" 1 35	0'3615	
512	Buxar	7 6 10	25 33 30	83 57 40	35 30	" 3 35	0'3630	
513	Malípur	7 6 4	26 16 10	82 38 50	36 40	" 1 50	0'3560	
514	Daryábád	7 6 2	26 51 30	81 33 00	37 50	" 2 0	0'3520	

*Abstract showing the approximate magnetic values at stations observed at by No. 26
Party during season, 1903-04—contd.*

Serial No.	Name of Station.	Survey No.	Latitude.	Longitude.	Dip.	Declination.	Horizontal Force.	REMARKS.
			°	'	"	°	'	
515	Gonda . . .	28 58 4	27 8 30	81 58 20	38 25	E 2 0	0°3505	
516	Tulsipur . . .	28 3	27 31 30	82 24 40	38 55	" 2 10	0°3495	
517	Nánpára . . .	28 2	27 51 40	81 31 10	39 20	" 2 15	0°3485	
518	Katarnian Ghát . . .	28 1	28 19 50	81 7 50	40 10	" 2 20	0°3460	
519	Basti . . .	28 1	26 49 10	82 46 30	37 50	" 1 55	0°3535	
520	Gorakhpur . . .	28 1	26 45 00	83 23 20	37 40	" 1 50	0°3540	
521	Uska-Bázár . . .	28 1	27 11 30	83 6 20	38 35	" 2 0	0°3510	
522	Bhatni . . .	28 3	26 23 00	83 55 40	36 55	" 1 50	0°3555	
523	Mau . . .	28 7	25 56 20	83 34 20	36 20	" 1 55	0°3550	
524	Azamgarh . . .	28 6	26 1 50	83 11 10	36 15	" 1 50	0°3565	
525	Aunrihar . . .	28 9	25 32 10	83 9 50	35 40	" 1 45	0°3580	
526	Siwán . . .	28 5	26 12 30	84 20 40	30 40	" 1 45	0°3565	
527	Chapra . . .	28 8	25 48 10	84 43 20	36 20	" 0 45	0°3595	
528	Muzaffarpur . . .	28 4	26 6 30	85 22 30	36 35	" 1 50	0°3590	
529	Pípra . . .	28 4	26 29 30	84 59 10	37 20	" 2 15	0°3565	
530	Bettiah . . .	28 2	26 48 50	84 31 30	37 45	" 2 0	0°3545	
531	Bairagnia . . .	28 1	26 43 50	85 16 30	38 0	" 1 55	0°3540	
532	Khanwa Ghát . . .	28 1	26 22 10	87 3 20	37 10	" 1 30	0°3570	
533	Nirmali . . .	28 2	26 18 00	86 34 00	36 55	" 1 55	0°3575	
534	Darbhangha . . .	28 3	26 6 00	85 54 20	36 50	" 1 45	0°3565	
535	Gwalior . . .	28 3	26 12 50	78 11 00	36 35	" 2 10	0°3505	
536	Mahona . . .	28 4	25 53 40	77 46 40	35 40	" 1 45	0°3535	
537	Sípri . . .	28 6	25 26 00	77 39 20	35 15	" 1 35	0°3520	
538	Bhind . . .	28 2	26 34 10	78 47 50	38 0	" 1 15	0°3480	
539	Datia . . .	28 5	25 38 40	78 27 30	35 0	" 1 20	0°3525	
540	Basai . . .	28 7	25 8 40	78 23 30	35 0	" 1 20	0°3530	
541	Lalitpur . . .	28 1	24 40 50	78 24 10	33 50	" 1 30	0°3600	
541(a)	Lalitpur (a) . . .	28 1	24 41 10	78 25 50	34 0	" 1 30	0°3590	
542	Pachhár . . .	28 2	24 34 50	77 43 40	33 45	" 1 20	0°3565	
543	Dharnáoda . . .	28 3	24 35 50	77 5 50	34 0	" 1 45	0°3545	
544	Bárán . . .	28 5	25 5 30	76 30 30	34 45	" 1 35	0°3530	
545	Bína . . .	28 4	24 10 50	78 11 00	32 25	" 1 20	0°3610	
546	Bhilása . . .	28 6	23 31 10	77 48 50	32 30	" 2 30	0°3560	
547	Bhopal . . .	28 7	23 15 50	77 24 30	31 25	" 1 20	0°3605	
548	Hoshangabad . . .	28 1	22 45 10	77 43 00	30 15	" 1 10	0°3635	
549	Pagdhál . . .	28 4	22 24 50	77 21 10	29 50	" 1 15	0°3625	
550	Pipláni . . .	28 3	22 7 10	76 47 30	30 0	" 1 40	0°3585	
551	Khandwa . . .	28 4	21 49 20	76 21 50	29 10	" 0 45	0°3665	
552	Burhánpur . . .	28 5	21 20 10	76 11 40	27 20	" 1 5	0°3660	
553	Sindkheda . . .	28 10	21 14 10	74 44 20	26 50	" 0 55	0°3670	
554	Nandurbár . . .	28 9	21 22 30	77 14 40	27 45	" 1 0	0°3625	
555	Jalgaon . . .	28 2	21 1 20	75 33 40	26 45	" 0 50	0°3650	
556	Barwaha . . .	28 2	22 15 20	76 1 30	29 5	" 1 5	0°3640	
557	Indore . . .	28 1	22 42 10	75 52 40	30 0	" 1 10	0°3655	
558	Barnagar . . .	28 6	23 3 50	75 22 30	31 15	" 1 25	0°3595	
559	Tarána Road . . .	28 4	23 15 40	76 3 50	31 10	" 1 25	0°3580	
560	Shujáulpur . . .	28 5	23 23 00	76 43 40	32 5	" 1 50	0°3595	
561	Sohágpur . . .	28 3	22 41 30	78 11 20	29 15	" 1 15	0°3625	
562	Mohpáni . . .	28 2	22 44 40	78 50 20	30 5	" 1 15	0°3650	
563	Narsinghpur . . .	28 1	22 55 50	79 12 30	30 35	" 1 30	0°3635	
564	Mirganj . . .	28 6	23 9 40	79 46 50	31 30	" 1 20	0°3580	
565	Sleemanábád . . .	28 5	23 36 30	80 16 20	31 45	" 1 10	0°3665	
566	Salaiya . . .	28 4	23 51 10	79 58 20	31 ..	" 1 30	0°3620	
567	Damoh . . .	28 3	23 50 00	79 26 00	32 30	" 1 25	0°3600	
568	Saugor . . .	28 1	23 50 50	78 44 20	32 15	" 1 50	0°3615	
569	Dholpur . . .	28 1	26 41 50	77 54 20	37 35	" 1 50	0°3495	
570	Agra Cant. . .	28 9	27 10 40	78 0 20	38 10	" 2 0	0°3470	
571	Shikhabad . . .	28 10	27 4 30	78 35 30	38 5	" 2 10	0°3485	
572	Achálada . . .	28 3	26 41 50	79 24 50	37 30	" 2 0	0°3510	
573	Cawnpore . . .	28 4	26 27 00	80 21 00	36 55	" 2 0	0°3535	
574	Kálpi . . .	28 5	26 7 00	79 45 50	36 20	" 1 50	0°3540	
575	Púnch . . .	28 7	25 49 00	79 2 50	35 50	" 1 40	0°3535	
576	Mau Ránipur . . .	28 8	25 15 10	79 9 10	35 0	" 1 35	0°3555	
577	Mahoba . . .	28 9	25 18 10	79 50 40	35 0	" 1 50	0°3545	
578	Atarra . . .	28 10	25 17 20	80 34 10	35 5	" 1 40	0°3565	
579	Sutna . . .	28 1	24 34 20	80 50 00	33 55	" 1 40	0°3600	
580	Amdara . . .	28 2	24 6 10	80 34 40	32 45	" 1 20	0°3620	
581	Málwa . . .	28 6	26 0 50	80 40 00	36 10	" 1 45	0°3535	
582	Araul . . .	28 1	26 55 00	80 1 40	37 55	" 1 55	0°3510	
583	Farukhbád . . .	28 11	27 23 10	79 34 40	38 40	" 2 5	0°3475	
584	Ganj Dundwára . . .	28 8	27 43 30	78 56 20	39 10	" 2 15	0°3460	
585	Kherli . . .	28 8	27 12 10	77 1 30	38 10	" 2 10	0°3465	
586	Aligarh . . .	28 7	27 53 40	78 4 20	39 20	" 2 10	0°3450	
587	Dhanári . . .	28 6	28 19 50	78 30 20	40 0	" 2 10	0°3435	
588	Aonla . . .	28 6	28 17 50	79 10 10	40 0	" 2 20	0°3440	
589	Míránpur Katra . . .	28 5	28 2 20	79 40 20	39 45	" 2 10	0°3450	



*Abstract showing the approximate magnetic values at stations observed at by No. 26
Party during season, 1903-04—concl.*

Serial No.	Name of Station.	Survey No.	Latitude.	Longitude.	Dip.	Declination.	Horizontal Force.	REMARKS.
			° ° "	° ° °	°	° °	C. G. S.	
590	Anjhi . .	28 80 9	27 38 20	79 59 20	30 0	E 2 5	0'3475	
591	Sanoda . .	12	27 7 00	80 25 10	38 10	" 2 0	0'3495	
592	Kamalpur . .	10	27 22 30	80 49 40	38 35	" 2 0	0'3490	
593	Lakhimpur . .	7	27 56 20	80 46 20	39 30	" 2 10	0'3460	
594	Chandan Chauki . .	3	28 32 20	80 46 40	40 30	" 2 20	0'3450	
595	Khutár . .	4	28 12 00	80 15 40	40 0	" 2 10	0'3450	
596	Sháhgarh . .	2	28 33 30	80 3 10	40 30	" 2 20	0'3435	
597	Richha Road . .	1	28 43 00	79 29 30	40 45	" 2 20	0'3430	
598	Káthgodám . .	20 80 1	29 15 20	79 32 50	41 40	" 2 30	0'3390	
599	Gárhmuktesar . .	28 78 4	28 46 40	78 4 00	40 55	" 2 30	0'3410	
600	Chola . .	5	28 18 30	77 43 40	40 15	" 2 20	0'3420	
601	Moradabad . .	3	28 50 00	78 45 30	41 0	" 2 25	0'3415	
602	Nagína . .	20 78 10	29 25 50	78 25 00	41 55	" 2 35	0'3380	

Repeat stations.

I	Udaipur . .		24 35 33	73 41 57	33 25	E 1 30	0'3535	
II	Karachi . .		24 49 50	67 2 2	33 40	" 1 0	0'3470	
III	Quetta . .		30 11 52	67 0 20	42 45	" 2 55	0'3245	
IV	Báhawalpur . .		29 23 27	71 40 37	41 40	" 2 50	0'3330	
V	Ráwalpindi . .		33 35 16	73 3 6	47 55	" 3 40	0'3135	
VI	Bharatpur . .		27 13 31	77 29 28	38 20	" 2 05	0'3465	
VII	Bangalore . .		12 59 35	77 35 58	9 25	W 0 25	0'3815	
VIII	Dhárwár . .		15 27 26	74 59 35	15 0	E 0 0	0'3765	
IX	Porbandar . .		21 38 20	69 37 6	28 20	" 1 15	0'3610	
X	Fyzabad . .		26 47 27	82 7 40	37 35	" 1 55	0'3535	
XI	Sambalpur . .		21 28 3	83 58 26	27 35	" 1 05	0'3720	
XII	Waltair . .		17 42 54	83 19 1	20 55	" 0 30	0'3775	
XIII	Darjeeling . .		26 59 49	88 16 39	...	" 1 50	0'3565	
XIV	Gaya . .		24 46 30	84 58 54	34 0	" 1 25	0'3660	
XV	Secunderábád . .		17 27 11	78 29 16	19 50	" 0 40	0'3790	
XVI	Bhusával . .		21 2 46	75 47 18	26 35	" 1 0	0'3685	
XVII	Jubbulpore . .		23 8 57	79 56 44	30 40	" 1 15	0'3650	No dip ob- served.

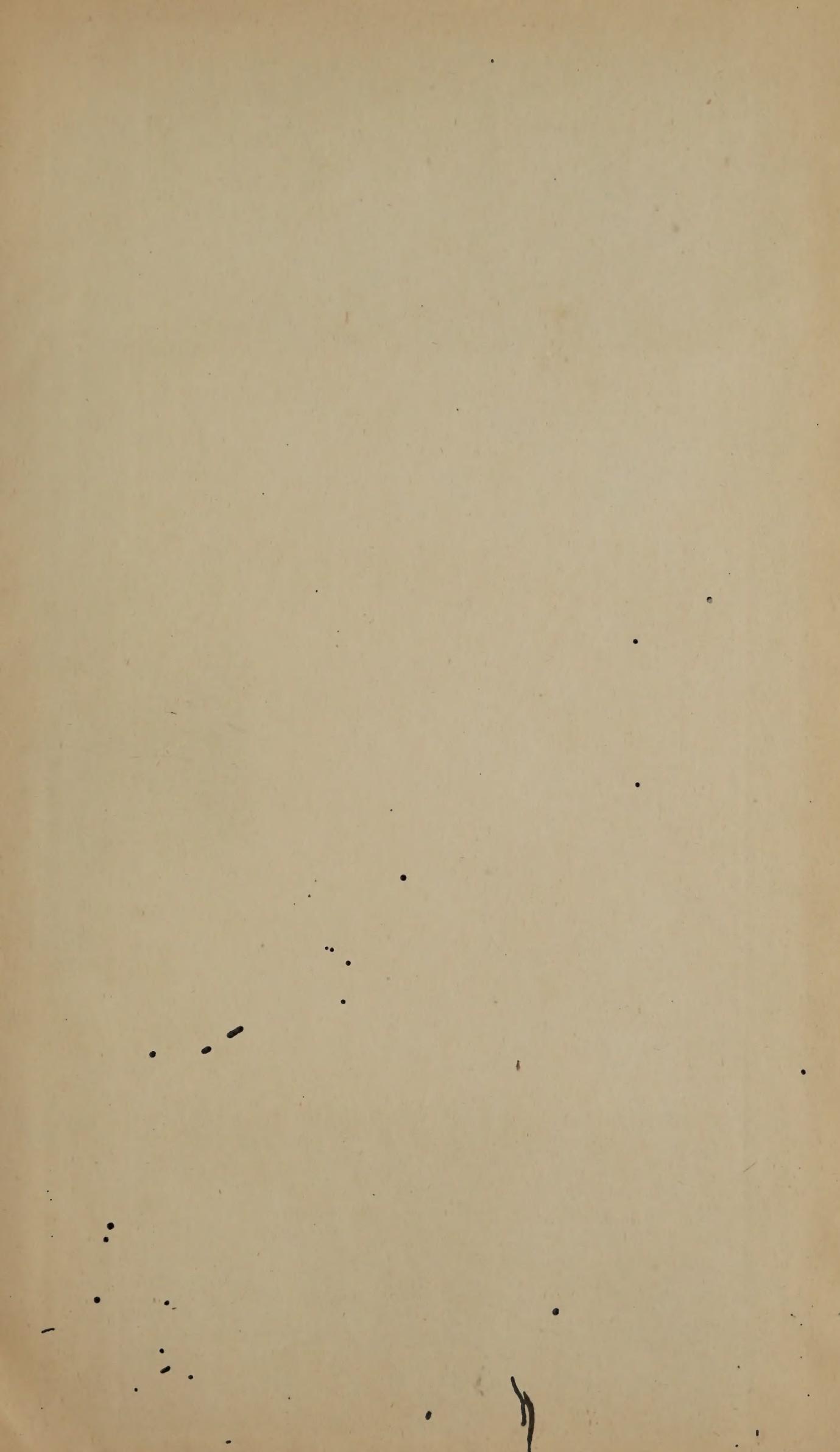
NOTE.—The above values of Dip Declination, and Horizontal Force are uncorrected for secular change, diurnal variation, instrumental differences, etc., and are to be considered as preliminary values only.

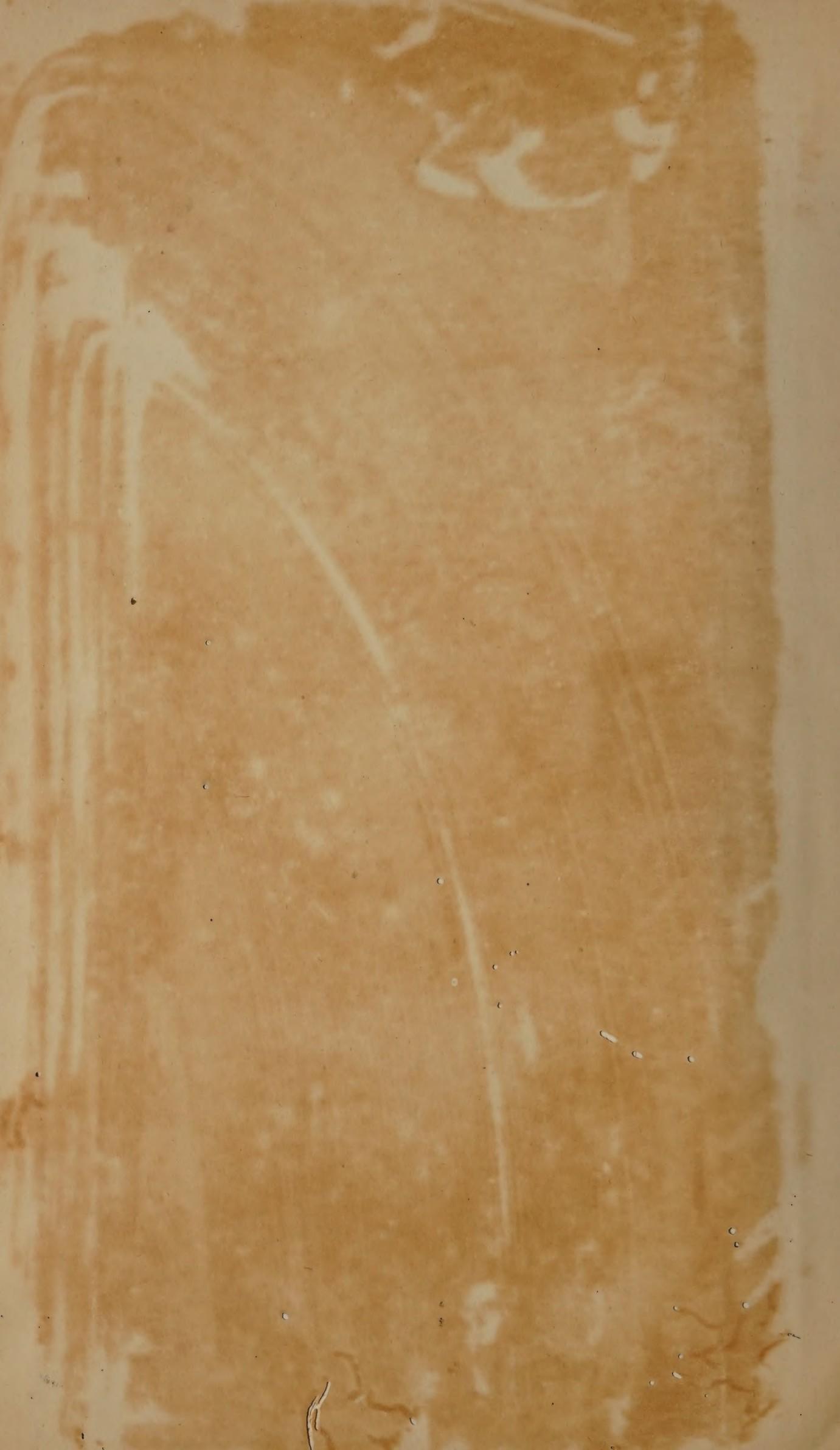
Where blanks occur, values have been already found during previous field seasons, or the observations have not been completed.

The Survey numbers refer to the published chart: thus No. 28 3 denotes No. 3 Station in the dotted square, the spherical co-ordinates of whose centre are 26° North Latitude and 76° East Longitude.

All Longitudes are referable to that of Madras Observatory taken at the value 80° 14' 47" East from Greenwich.

THE LIBRARY OF THE
JUL 22 1929
UNIVERSITY OF ILLINOIS









3 0112 118841359

GENERAL REPORT
ON THE
OPERATIONS
OF THE
Survey of India
ADMINISTERED UNDER
THE GOVERNMENT OF INDIA
DURING
1903-04.

PREPARED UNDER THE DIRECTION OF
COLONEL J. R. HOBDAY, I.A.,
OFFICIATING SURVEYOR GENERAL OF INDIA.



CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1905.

Price Two Rupees or Three Shillings.